MISCELLANEOUS PAPER CERC-88-12

COASTAL PROCESSES AT SEA BRIGHT TO OCEAN TOWNSHIP, NEW JERSEY

VOLUME II: APPENDIXES B-G

by

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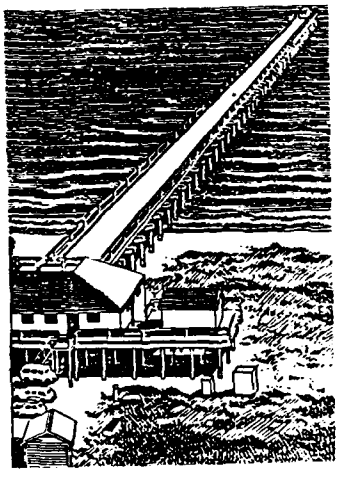

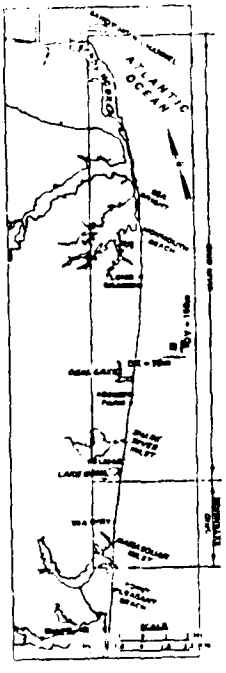

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APPENDIX B: WIS HINDCAST SUMMARY

1. This appendix provides information on the Wave Information Study (WIS) Phase III hindcast wave data. Included is a summary of wave statistics for the 20-year period 1956 - 1975. Table B1 gives the statistics categorized by wave approach angle in degrees. Values in the direction tables represent the percent of the 20 years that waves occur from the specified direction bands for the indicated height and period ranges. The values have been multiplied by 1,000 to allow more accuracy with less printing space. Summations are provided in the last column and row of each table. Table B2 is a summary of the same data for waves from all directions. Values in Table B2 are multiplied by 100. The parameters listed in the last line of the all-direction table are derived from all preceding directional tables for the full 20 years. There were 58,440 cases analyzed, but not all cases resulted in finite wave conditions. Approximately 15.77 percent of the wave conditions at station 54 were considered calm. The angle class percentage found in each angle class table has been rounded to the nearest 0.1 percent in the all-directions table and in summing the percent occurrence found in the individual angle class tables.

2. Table B3 is a summary of the 200 largest wave heights ranked in descending order, together with the corresponding date, wave period, and wave direction measured from the south.

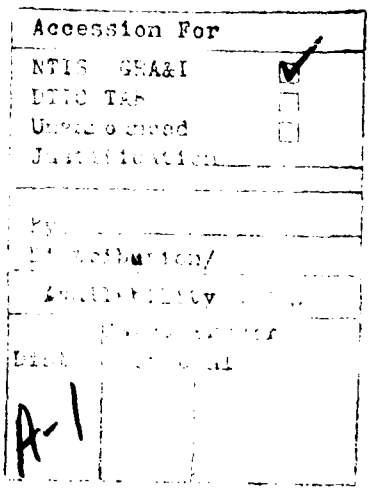


Table B1

Wave Statistics Categorized by Wave Approach Angle

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 0. - 11.24
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	.	.	.	.	.	.	0
1.00 - 1.49	.	.	.	.	.	.	.	.	.	.	0
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	0	0	0	0	0	0	0	0	0	

AVERAGE HS(M) = 0. LARGEST HS(M) = 0. ANGLE CLASS % = 0.

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 11.25 - 33.74
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	.	.	.	.	.	.	0
1.00 - 1.49	.	.	.	.	.	.	.	.	.	.	0
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	0	0	0	0	0	0	0	0	0	

AVERAGE HS(M) = 0. LARGEST HS(M) = 0. ANGLE CLASS % = 0.

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 33.75 - 56.24
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	.	.	.	.	.	.	.	.	.	.	0
0.50 - 0.99	.	.	.	.	.	.	.	.	.	.	0
1.00 - 1.49	.	.	.	.	.	.	.	.	.	.	0
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	0	0	0	0	0	0	0	0	0	0	

AVERAGE HS(M) = 0. LARGEST HS(M) = 0. ANGLE CLASS % = 0.

(Continued)

Table B1 (Continued)

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 56.25 - 78.74
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	569	1249	1377	1394	405	415	155	6	3	5	5578
0.50 - 0.99	.	3	244	710	167	268	109	18	10	.	1529
1.00 - 1.49	.	.	.	90	123	177	49	1	.	.	440
1.50 - 1.99	.	.	1	1	17	77	15	.	.	.	111
2.00 - 2.49	.	.	.	.	1	11	3	.	.	.	15
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	569	1252	1622	2195	713	948	331	25	13	5	

AVERAGE HS(M) = 0.37 LARGEST HS(M) = 2.37 ANGLE CLASS % = 7.7

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 78.75 - 101.24
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	499	850	46	.	925	1346	859	133	90	450	5198
0.50 - 0.99	.	306	1199	275	28	1434	1141	198	308	788	5676
1.00 - 1.49	.	1	65	687	195	378	504	92	85	148	2155
1.50 - 1.99	.	.	.	61	318	287	225	47	20	63	1021
2.00 - 2.49	.	.	.	.	68	292	138	11	8	30	547
2.50 - 2.99	.	.	.	.	13	123	75	1	6	18	236
3.00 - 3.49	.	.	.	.	6	22	37	.	.	5	70
3.50 - 3.99	.	.	.	.	.	.	5	5	.	3	13
4.00 - 4.49	.	.	.	.	.	.	.	6	.	6	12
4.50 - 4.99	.	.	.	.	.	.	.	1	.	1	2
5.00 - GREATER	.	.	.	.	.	.	.	.	5	10	15
TOTAL	499	1157	1310	1023	1554	3880	2984	494	522	1522	

AVERAGE HS(M) = 0.83 LARGEST HS(M) = 6.87 ANGLE CLASS % = 15.0

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 101.25 - 123.74
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	453	542	.	.	277	540	2186	973	280	203	5454
0.50 - 0.99	.	530	936	.	3	270	533	205	254	61	2792
1.00 - 1.49	.	1	140	503	3	66	80	29	49	10	881
1.50 - 1.99	.	.	.	65	165	25	37	1	8	6	307
2.00 - 2.49	.	.	.	.	56	116	15	.	.	5	192
2.50 - 2.99	.	.	.	.	10	85	22	1	1	.	129
3.00 - 3.49	.	.	.	.	3	25	44	1	1	.	74
3.50 - 3.99	.	.	.	.	.	1	8	3	.	.	12
4.00 - 4.49	.	.	.	.	.	.	1	.	.	.	1
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	453	1073	1076	568	517	1138	2936	1213	593	285	

AVERAGE HS(M) = 0.62 LARGEST HS(M) = 4.06 ANGLE CLASS % = 9.9

(Continued)

Table B1 (Concluded)

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 123.75 - 146.24
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	650	751	.	.	713	2612	29	260	472	701	6188
0.50 - 0.99	.	638	1036	5	15	631	80	118	319	51	2893
1.00 - 1.49	.	1	133	516	20	152	29	22	63	1	937
1.50 - 1.99	.	.	.	65	145	61	13	15	23	13	335
2.00 - 2.49	.	.	.	.	51	142	20	6	6	6	231
2.50 - 2.99	.	.	.	.	10	54	47	13	3	1	128
3.00 - 3.49	.	.	.	.	6	10	15	13	1	.	45
3.50 - 3.99	.	.	.	.	.	.	1	6	.	.	7
4.00 - 4.49	.	.	.	.	.	.	.	1	.	.	1
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	650	1390	1169	586	960	3662	234	454	887	773	

AVERAGE HS(M) = 0.61 LARGEST HS(M) = 4.14 ANGLE CLASS % = 10.8

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 146.25 - 168.74
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	1281	2369	152	.	2932	7679	3966	56	.	.	18435
0.50 - 0.99	.	561	2262	763	181	1865	1098	44	.	.	6774
1.00 - 1.49	.	.	61	564	395	504	304	29	.	.	1857
1.50 - 1.99	.	.	.	22	165	251	100	15	.	.	553
2.00 - 2.49	.	.	.	.	34	118	49	5	.	.	206
2.50 - 2.99	.	.	.	.	6	18	10	3	.	.	37
3.00 - 3.49	.	.	.	.	1	1	.	.	.	.	2
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1281	2930	2475	1349	3714	10436	5527	152	0	0	

AVERAGE HS(M) = 0.49 LARGEST HS(M) = 3.09 ANGLE CLASS % = 27.9

STATION 54 20 YEARS WAVE APPROACH ANGLE(DEGREES)= 168.75 - 180.00
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD BY DIRECTION

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	1598	3759	3704	2397	292	32	.	.	.	.	11732
0.50 - 0.99	.	1	600	686	186	11	.	.	.	.	1484
1.00 - 1.49	.	.	.	1	3	.	.	.	.	.	4
1.50 - 1.99	.	.	.	.	.	.	.	.	.	.	0
2.00 - 2.49	.	.	.	.	.	.	.	.	.	.	0
2.50 - 2.99	.	.	.	.	.	.	.	.	.	.	0
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1598	3760	4304	3084	481	43	0	0	0	0	

AVERAGE HS(M) = 0.24 LARGEST HS(M) = 1.10 ANGLE CLASS % = 13.3

(Sheet 3 of 3)

Table B2

Wave Statistics for the 20-Year Period (1956-1975)

STATION 54 20 YEARS FOR ALL DIRECTIONS
WAVE APPROACH ANGLES RELATIVE TO TRUE NORTH
WATER DEPTH = 18.29 METERS
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METERS)	PERIOD(SECONDS)										TOTAL
	0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	
0. - 0.49	505	952	528	379	554	1262	719	143	84	136	5262
0.50 - 0.99	.	204	627	244	58	447	296	58	89	90	2113
1.00 - 1.49	.	.	40	236	74	127	97	17	19	16	626
1.50 - 1.99	.	.	.	21	81	70	39	8	5	8	232
2.00 - 2.49	.	.	.	.	21	68	22	2	1	4	118
2.50 - 2.99	.	.	.	.	4	29	15	2	1	2	53
3.00 - 3.49	.	.	.	.	1	5	9	1	.	.	16
3.50 - 3.99	.	.	.	.	.	.	1	1	.	.	2
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	1	1
TOTAL	505	1156	1195	880	793	2008	1198	232	199	257	

AVE HS(M) = 0.45 LARGEST HS(M) = 6.87 TOTAL CASES = 58440

Table B3

Highest 200 Wave Heights in 20-Year Hindcast

RANK	COUNT	DATE (YYMMDDHH)	HEIGHT (m)	PERIOD (sec)	DIRECTION* (deg)
**********		1 1	1	1 1	1
1	1	62030618	6.90	10.00	95.30
2	2	62030703	6.10	13.00	92.40
3	3	62030700	6.10	13.00	94.30
4	4	62030615	6.00	10.00	95.00
5	5	62030706	5.80	13.00	92.40
6	6	62030709	5.50	13.00	92.40
7	7	62030621	5.50	10.00	98.50
8	8	62030712	5.20	13.00	92.40
9	9	62030715	5.00	13.00	92.40
10	10	62030718	4.70	13.00	92.40
**********		2 2	2	2 2	2
11	11	72021918	4.60	9.00	85.50
12	12	62030721	4.30	13.00	92.40
13	13	62030609	4.30	9.00	97.90
14	14	62030803	4.30	13.00	94.30
15	15	62030806	4.30	13.00	94.30
16	16	62030800	4.20	13.00	93.00
**********		3 3	3	3 3	3
17	17	74120203	4.20	9.00	88.30
18	18	74120206	4.10	9.00	88.90
19	19	74120209	4.10	9.00	84.30
**********		4 4	4	4 4	4
20	20	73120921	4.10	9.00	57.00
21	21	73120918	4.10	8.00	73.20
22	22	74120200	4.00	9.00	87.80
23	23	74120212	3.90	9.00	72.50
24	24	62030809	3.90	13.00	94.90
25	25	62030612	3.80	9.00	98.30
**********		5 5	5	5 5	5
26	26	66012321	3.70	9.00	66.90
27	27	74120121	3.70	8.00	88.70
**********		6 6	6	6 6	6
28	28	75031921	3.70	9.00	52.20
29	29	74120215	3.60	8.00	54.80
**********		7 7	7	7 7	7
30	30	75121000	3.60	8.00	69.40
31	31	73121000	3.60	9.00	42.40
32	32	73120915	3.60	8.00	87.60
**********		8 8	8	8 8	8
33	33	74033103	3.60	8.00	88.70
**********		9 9	9	9 9	9
34	34	73102921	3.60	8.00	77.60
35	35	73102918	3.60	8.00	81.10
**********		10 10	10	10 10	10
36	36	60121203	3.60	7.00	79.90
37	37	62030812	3.60	13.00	95.50
**********		11 11	11	11 11	11
38	38	62110400	3.60	8.00	76.80
**********		12 12	12	12 12	12
39	39	64011321	3.60	9.00	98.30
**********		13 13	13	13 13	13
40	40	69122621	3.60	8.00	65.60

*Direction measured from south.

(Continued)

Table B3 (Continued)

**********		14	14	14	14	14	14
41	41	70121715		3.50		9.00	82.40
42	42	75032000		3.50		9.00	51.00
43	43	75031918		3.50		9.00	55.10
44	44	75121003		3.40		8.00	65.60
**********		15	15	15	15	15	15
45	45	56011021		3.40		11.00	94.90
46	46	74033106		3.40		8.00	64.10
**********		16	16	16	16	16	16
47	47	61020412		3.40		8.00	95.20
**********		17	17	17	17	17	17
48	48	60073015		3.40		7.00	55.30
**********		18	18	18	18	18	18
49	49	60021909		3.40		8.00	74.70
50	50	70121718		3.40		9.00	54.50
51	51	70121703		3.40		7.00	70.60
**********		19	19	19	19	19	19
52	52	69110312		3.40		8.00	56.80
53	53	64011318		3.40		8.00	97.10
54	54	62110321		3.40		7.00	92.80
**********		20	20	20	20	20	20
55	55	62122203		3.40		7.00	71.40
56	56	66012318		3.40		8.00	61.90
57	57	66012312		3.40		7.00	86.20
58	58	62030815		3.30		13.00	97.30
**********		21	21	21	21	21	21
59	59	64012021		3.30		7.00	56.10
**********		22	22	22	22	22	22
60	60	64020621		3.30		7.00	62.40
**********		23	23	23	23	23	23
61	61	65012421		3.30		8.00	70.20
62	62	65012418		3.30		8.00	76.10
63	63	69122618		3.30		8.00	69.40
64	64	69122221		3.30		8.00	78.30
**********		24	24	24	24	24	24
65	65	68110715		3.30		7.00	86.20
**********		25	25	25	25	25	25
66	66	68031809		3.30		7.00	96.40
**********		26	26	26	26	26	26
67	67	71021321		3.30		6.00	53.10
68	68	70121712		3.30		8.00	76.80
69	69	72021912		3.30		8.00	91.00
**********		27	27	27	27	27	27
70	70	72031509		3.30		8.00	82.40
**********		28	28	28	28	28	28
71	71	72020403		3.30		8.00	50.00
**********		29	29	29	29	29	29
72	72	59030615		3.30		6.00	43.10
**********		30	30	30	30	30	30
73	73	58110309		3.30		8.00	73.90
**********		31	31	31	31	31	31
74	74	58102221		3.30		8.00	81.80
75	75	58102218		3.30		8.00	84.40
76	76	61020409		3.30		8.00	89.90
77	77	61020406		3.30		7.00	86.20

(Continued)

Table B3 (Continued)

78	78	73102915	3.30		8.00	83.80
79	79	73103000	3.30		8.00	73.90
**********		32 32	32	32	32	32
80	80	73020221	3.30		8.00	44.00
81	81	75120921	3.30		8.00	72.50
82	82	75120918	3.30		8.00	76.80
83	83	75032003	3.30		9.00	50.50
84	84	75032006	3.30		10.00	62.40
85	85	74120118	3.30		7.00	89.80
**********		33 33	33	33	33	33
86	86	74121703	3.30		8.00	52.70
87	87	75031915	3.20		8.00	55.40
88	88	75120915	3.20		8.00	80.40
89	89	56011100	3.20		11.00	94.90
**********		34 34	34	34	34	34
90	90	72112612	3.20		6.00	44.50
91	91	74033100	3.20		8.00	98.40
**********		35 35	35	35	35	35
92	92	73122109	3.20		9.00	42.40
93	93	73122106	3.20		9.00	44.30
94	94	73122103	3.20		9.00	48.20
95	95	73122100	3.20		8.00	48.80
**********		36 36	36	36	36	36
96	96	60022606	3.20		7.00	60.10
97	97	60022609	3.20		8.00	53.40
**********		37 37	37	37	37	37
98	98	57100621	3.20		7.00	84.80
99	99	72031512	3.20		8.00	75.40
100	100	72021915	3.20		8.00	100.40
**********		38 38	38	38	38	38
101	101	67121121	3.20		8.00	76.80
**********		39 39	39	39	39	39
102	102	65022512	3.20		6.00	70.30
103	103	64011312	3.20		7.00	98.70
**********		40 40	40	40	40	40
104	104	64021615	3.20		6.00	83.00
**********		41 41	41	41	41	41
105	105	62031215	3.20		7.00	55.30
106	106	62031218	3.20		9.00	59.50
107	107	62031221	3.20		9.00	58.90
108	108	62110403	3.20		8.00	52.00
109	109	62031300	3.10		9.00	57.60
110	110	62030606	3.10		8.00	98.40
**********		42 42	42	42	42	42
111	111	64010115	3.10		6.00	77.70
112	112	66012315	3.10		7.00	79.20
113	113	67121115	3.10		7.00	79.90
114	114	67121118	3.10		8.00	79.80
**********		43 43	43	43	43	43
115	115	67120321	3.10		7.00	82.70
**********		44 44	44	44	44	44
116	116	67122818	3.10		6.00	86.00
117	117	68110800	3.10		8.00	79.80
**********		45 45	45	45	45	45
118	118	69012121	3.10		8.00	92.70

(Continued)

Table B3 (Continued)

**********		46	46	46	46	46	46
119	119	70040215	3.10		6.00	42.40
120	120	72021903	3.10		6.00	87.90
121	121	72020400	3.10		7.00	82.70
**********		47	47	47	47	47	47
122	122	71030409	3.10		7.00	66.50
**********		48	48	48	48	48	48
123	123	71112518	3.10		8.00	76.10
124	124	57100618	3.10		7.00	91.70
125	125	58102212	3.10		8.00	88.70
126	126	58102215	3.10		8.00	87.00
127	127	74033015	3.10		8.00	98.80
128	128	74033018	3.10		8.00	100.40
**********		49	49	49	49	49	49
129	129	72110821	3.10		7.00	51.60
130	130	73020218	3.10		8.00	51.30
131	131	73103003	3.10		8.00	67.90
132	132	73102912	3.10		7.00	84.80
133	133	75120912	3.10		8.00	83.80
134	134	74120218	3.10		7.00	37.40
135	135	74121700	3.00		8.00	71.00
136	136	74121621	3.00		7.00	75.30
137	137	75032009	3.00		10.00	62.40
138	138	75121006	3.00		10.00	84.70
139	139	56011103	3.00		11.00	94.20
140	140	73103006	3.00		8.00	57.50
141	141	73020215	3.00		7.00	54.50
142	142	74033021	3.00		8.00	100.40
143	143	74033109	3.00		7.00	36.30
144	144	73122021	3.00		7.00	50.10
145	145	73122112	3.00		10.00	47.30
146	146	73122115	3.00		9.00	37.40
147	147	73120912	3.00		7.00	94.30
**********		50	50	50	50	50	50
148	148	74012112	3.00		6.00	54.80
149	149	58102209	3.00		8.00	90.50
150	150	58102206	3.00		8.00	91.00
151	151	58102121	3.00		7.00	89.80
152	152	58102300	3.00		8.00	80.40
153	153	58110306	3.00		7.00	79.90
**********		51	51	51	51	51	51
154	154	59031221	3.00		7.00	70.60
155	155	60021906	3.00		8.00	71.00
156	156	60021903	3.00		7.00	79.90
**********		52	52	52	52	52	52
157	157	60020106	3.00		7.00	95.30
158	158	57100700	3.00		7.00	81.30
159	159	57100703	3.00		8.00	95.20
**********		53	53	53	53	53	53
160	160	58011500	3.00		7.00	93.30
**********		54	54	54	54	54	54
161	161	56092715	3.00		8.00	103.00
**********		55	55	55	55	55	55
162	162	61112421	3.00		7.00	68.90
163	163	71112515	3.00		8.00	80.40

(Continued)

(Sheet 4 of 5)

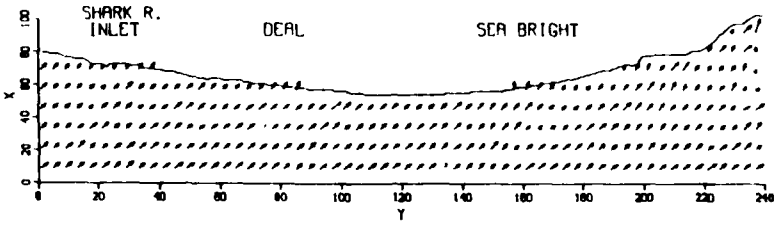
Table B3 (Concluded)

164	164	71030412	3.00		8.00	34.50
165	165	70121709	3.00		7.00	76.00
166	166	72022000	3.00		6.00	22.00
167	167	72031506	3.00		8.00	84.40
168	168	69122615	3.00		7.00	82.00
169	169	69110209	3.00		6.00	72.80
170	170	69110221	3.00		7.00	83.40
171	171	69110306	3.00		8.00	89.90
**********		56 56	56	56	56	56
172	172	70110506	3.00		7.00	71.40
173	173	69012118	3.00		7.00	92.30
174	174	68110803	3.00		8.00	83.10
**********		57 57	57	57	57	57
175	175	68011412	3.00		6.00	85.20
176	176	67121203	3.00		7.00	65.70
177	177	67121200	3.00		8.00	73.90
**********		58 58	58	58	58	58
178	178	68052915	3.00		8.00	83.80
179	179	68052918	3.00		7.00	76.00
**********		59 59	59	59	59	59
180	180	64112603	3.00		7.00	53.80
181	181	65022518	3.00		7.00	65.70
182	182	65012500	3.00		8.00	54.80
183	183	65012415	3.00		8.00	79.00
**********		60 60	60	60	60	60
184	184	62111012	3.00		7.00	60.80
185	185	62122209	3.00		7.00	64.10
186	186	62122212	2.90		8.00	53.40
187	187	62111003	2.90		7.00	76.80
188	188	62030818	2.90		13.00	97.30
189	189	62031309	2.90		9.00	48.00
**********		61 61	61	61	61	61
190	190	62032303	2.90		11.00	87.20
191	191	62032300	2.90		11.00	88.60
192	192	65012412	2.90		7.00	80.60
193	193	65022521	2.90		8.00	57.50
194	194	64010121	2.90		7.00	62.40
**********		62 62	62	62	62	62
195	195	63110721	2.90		7.00	83.40
196	196	64021915	2.90		8.00	73.20
197	197	64011315	2.90		7.00	100.40
198	198	68052912	2.90		8.00	87.60
199	199	67121206	2.90		7.00	55.30
200	200	67120315	2.90		6.00	42.40

APPENDIX C: WAVE REFRACTION PATTERNS

1. This appendix contains plots showing the results of selected refraction model runs which were used to verify proper operation of the wave refraction model and to give a visualization of the results. Each page contains two plots for a given wave approach angle.

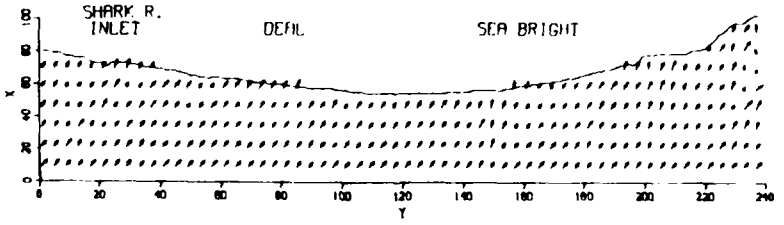
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-67.5 DEG
T : 7.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

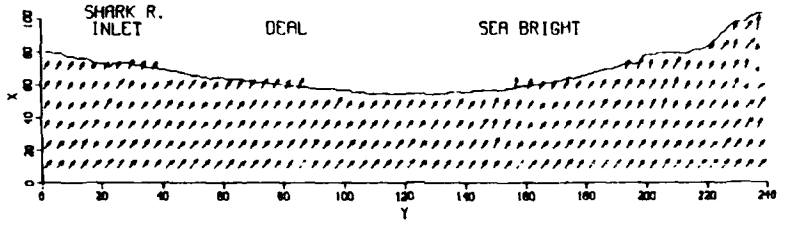
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-67.5 DEG
T : 10.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

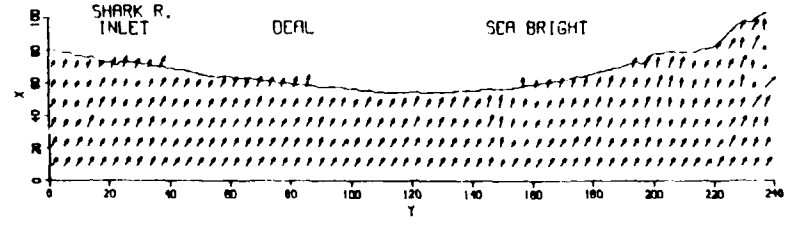
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-52.5 DEG
T : 7.5 SEC
H : 1.0 M

1 1.0-M WAVE HEIGHT

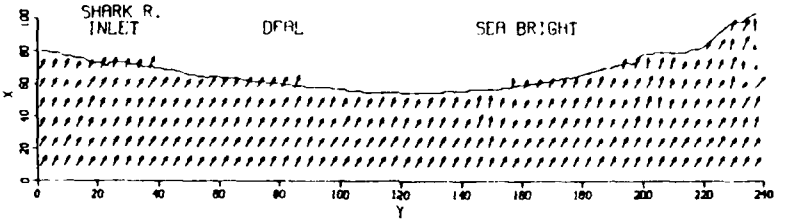
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-52.5 DEG
T : 10.5 SEC
H : 1.0 M

1 1.0-M WAVE HEIGHT

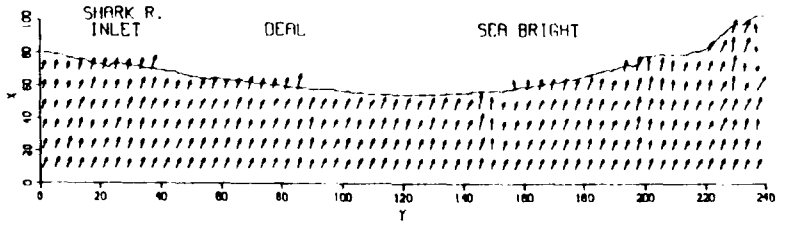
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-37.5 DEG
T : 7.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

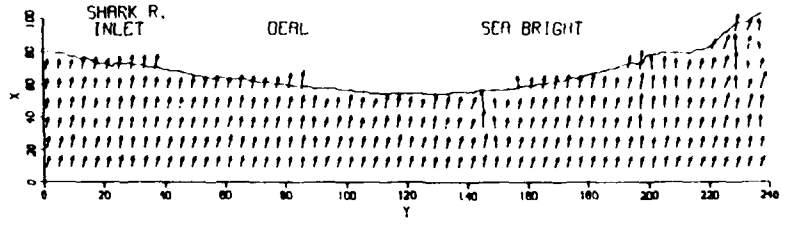
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-37.5 DEG
T : 10.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

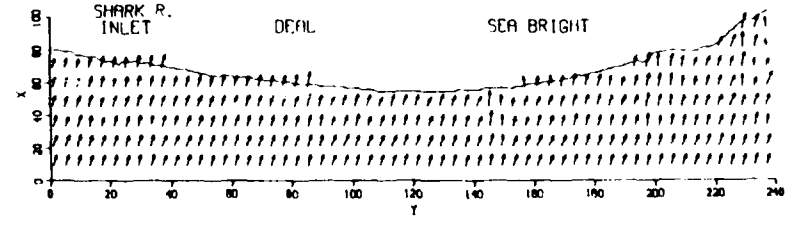
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-22.5 DEG
T : 10.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

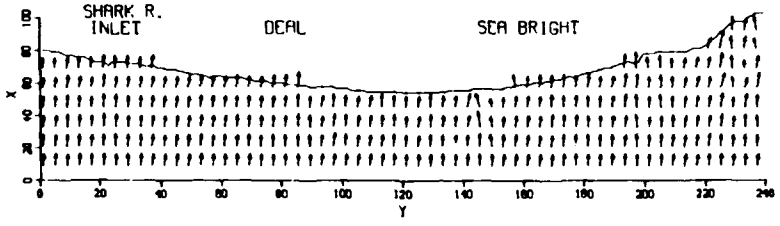
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-22.5 DEG
T : 7.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

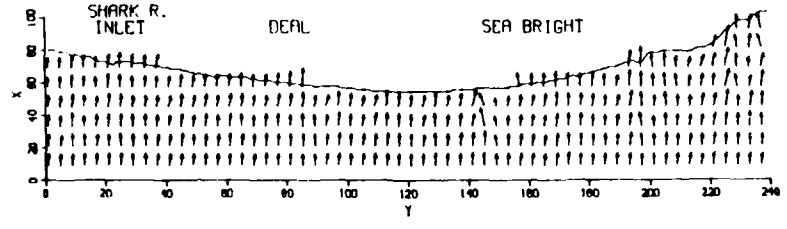
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-7.5 DEG
T : 7.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

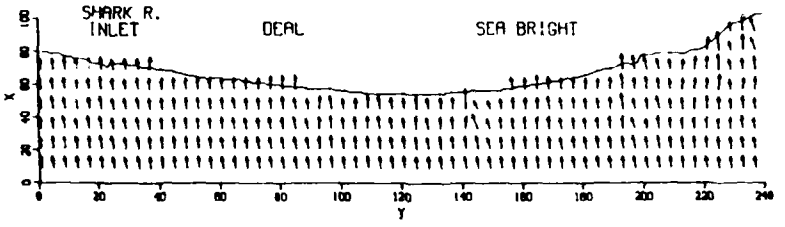
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ :-7.5 DEG
T : 10.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

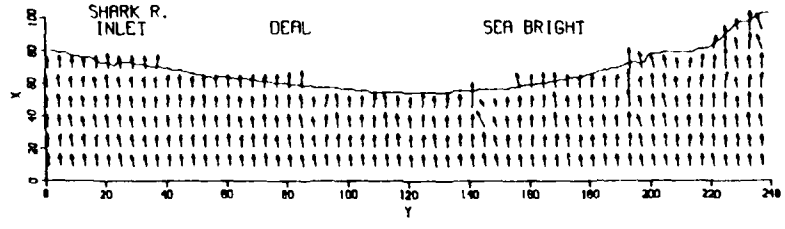
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ : 7.5 DEG
T : 7.5 SEC
H : 1.0 M

1.0-M WAVE HEIGHT

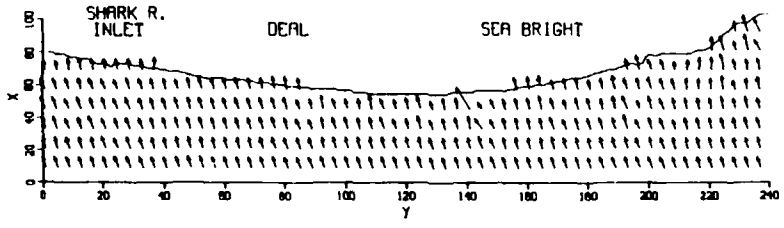
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ : 7.5 DEG
T : 10.5 SEC
H : 1.0 M

1.0-M WAVE HEIGHT

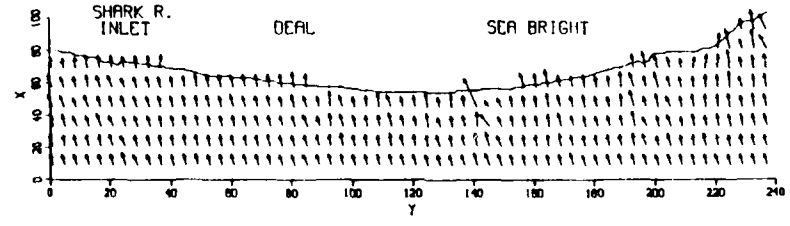
SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ : 22.5 DEG
T : 7.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

SEA BRIGHT WAVE TRANSFORMATION



DEEP WATER WAVE CONDITIONS
θ : 22.5 DEG
T : 10.5 SEC
H : 1.0 M

↑ 1.0-M WAVE HEIGHT

APPENDIX D: MEASURED SHORELINE AND BEACH PROFILE CHANGE

1. This appendix provides measured shoreline, profile, and sediment grain size information for the north New Jersey coast from Sandy Hook to Shark River Inlet.

Shoreline Change

2. The 17.6-mile long (28.4 km) study area from Sandy Hook south to Shark River Inlet, was divided into 24 blocks to facilitate an evaluation of local shoreline and beach profile change (Figure D1). Each block is approximately three-fourths of a mile (1,180 m) in length; the longest block is one mile long and the shortest is one-half mile long. These shoreline blocks are named according to the townships which border each particular stretch of beach. Table D1 lists the number, name, length, and number of grid cells used in the shoreline change model for each block.

3. Thirteen sets of historical shoreline position data were available for the study area (Table D2). These sets date from 1836 to 1985. Shoreline positions (estimated position of the high water line) were digitized at approximate 25-m intervals from Mylar sheets made in this study from large-frame photographs of original shoreline survey maps provided by CENAN. These maps appear in reduced form in the the 1954 CE report (CE 1954). Digitized shoreline positions were transferred to a computer file for direct access by the shoreline change numerical model and other shoreline and profile analysis programs.

4. Time intervals selected for shoreline comparisons are listed in Table D3. For every time interval, the average annual rate of shoreline position change was calculated for each block and the study area as a whole. Results are presented in Tables D4-D18. The following discussion summarizes the tabulated data.

5. The first four shoreline change blocks are located in Sandy Hook National Gateway Recreational Park. Shoreline change in this area is highly variable in both direction and magnitude; blocks have experienced intervals of extreme shoreline advance and retreat during the last 150 years. For the period 1836-1855, the first two blocks show landward migration of the shoreline and the second two blocks show seaward migration of the shoreline

(Table D5). During the next period, 1855-1926 (Table D11), the trend is reversed, with seaward translation of the high water shoreline in the first two blocks and recession in the second two blocks. Between 1926 and 1953 (Table D15), the first three blocks experienced shoreline retreat while the fourth block exhibited advance. Additional comparisons over shorter time periods are given in Tables D4, D9, D10, and D14.

6. The remaining blocks extend from Navesink Beach (block 5) south to Avon or Shark River Inlet (block 24). Data for these blocks exist for the time period 1836-1985. This area has exhibited a more consistent trend of shoreline movement than the Sandy Hook blocks. The period 1836-1867 shows a nearly uniform retreat of the shoreline between Sea Bright and Allenhurst at a rate of approximately 2.9 m/yr (Table D6). This is the most severe recessional period found in the data set. The following period, 1867-1899, shows a decrease in the rate of landward migration of the shoreline to about 0.6 m/yr, with some blocks showing minor amounts of shoreline advance (Table D12). The next period, 1899-1932, again shows an overall decrease in the retreat rate to approximately 0.5 m/yr, with a few blocks showing seaward migration of the shoreline (Table D13).

7. An episode of shoreline advance occurred in the interval 1932-1953, representing a short-term reversal of the long-term recessional trend of this region during the past 96 years. Table D16 shows seaward translation of the high water line for all but three of the blocks during this time period. Two of the blocks exhibiting shoreline recession are at the northern end of the study area in the highly variable Sandy Hook region. A probable explanation for the reversal is the proliferation of coastal protection measures, such as groins and seawalls, which occurred just prior to and during this period. The presence of protective structures may have altered the supply of sediment reaching the northern end of the study area, possibly causing erosion of the first two blocks.

8. For the last available time period, 1953-1985, the shoreline again migrated landward. Table D18 shows this retreat at an average rate of 0.2 m/yr; however, about a fourth of the blocks show shoreline advance which is attributed in part to local nourishment projects.

9. Table D8 gives a summary of the available data from 1836 to 1985. It shows consistent shoreline recession from Navesink Beach south to Allenhurst at an average rate of 0.85 m/yr, and shoreline advance in the two blocks

north of Navesink. A similar trend is observed for the period 1836-1932, although the average rate of recession between Navesink Beach and Allenhurst is greater at 1.45 m/yr (Table D7). Table D17 shows that for the period 1932-1985, the shoreline position was essentially stable. This indicates that the shore protection measures taken have been successful.

Sediment Characteristics

10. Sediment data associated with the 1953 and 1985 profile surveys are presented in Table D19. These data are used in the evaluation of an equilibrium beach profile envelope as discussed below. The only physical parameter required to define an equilibrium profile is the mean (or some other representative) grain size. Therefore, a need existed to select a representative sediment size or sediment size range in order to estimate an equilibrium envelope to be compared to the measured profiles. The equilibrium profile and its use in this study are described in paragraphs 18-20.

11. For the 1953 data set, median grain size was reported (CE 1954) for the high water line, the low water line, and approximately every 6 ft of depth down to 30 ft MLW. It is assumed that the "high water line" and "low water line" referred to in the 1954 report are equivalent to mean high water and mean low water. For the 1985 data set, median grain size was given for elevations of 6 ft, mean low water, and every 6 ft of depth down to 30 ft MLW. For each data set, sediment sizes for all depths were averaged and the standard deviation was calculated.

12. The overall average median grain size was calculated to be 0.33 mm for the 1953 data and 0.30 mm for the 1985 data, suggesting that the median grain size for this region has remained relatively constant over the past three decades. Since it is a well established empirical result that average beach slope is in great part controlled by grain size, it may be inferred that the beach slope along the coast has not undergone notable change in the 32-yr period. This conclusion is quantitatively substantiated in the next section.

Profile Analysis

13. Profile data from the 1953, 1963, 1985, and 1986 surveys were plotted using the computer program ISRP (Interactive Survey Reduction Program)

(Birkemeier 1984).* All 1953 profile lines within the bounds of the study area were used and there typically is one profile line in each shoreline block. Table D19 shows the locations of profile lines in the block system used in this study. Profiles in the 1953 and 1963 surveys were numbered 1-26. A total of 68 profiles were surveyed in 1985 and 1986. To facilitate comparison, an extra digit was used in the 1985 and 1986 numbering system; thus, profile number 25 in the 1953 survey corresponds to profile 250 in the 1985 survey.

14. Comparison plots of profiles from the periods 1953 - 1963 and 1953 - 1985 have been prepared such that the elevation of 0.0 ft (NGVD) is located at the same horizontal position for both data sets to allow comparison of beach slope. These plots are presented in Figures D2 through D11 for the 1953 and 1985 data and Figures D12 through D19 for the 1953 and 1985 data and provide an indication of long-term changes in general profile slope. Changes in profile slopes are minimal considering the 10- and 32-year interval between surveys.

15. Comparison plots of the 1985 and 1986 profile data have been prepared to give a visual indication of seasonal variations (Figures D20-D26). It is noted that the beach profile is active in front of the seawall, occasionally exhibiting recovery behavior as evidenced by bar formation in Figures D25 and D26. Local scour at the toe of the seawall shows considerable variability for some profiles, e.g., Figures D4 (top), D10, and D16.

Representative profile slopes

16. An average profile was computed using data from profiles common to all surveys to obtain representative slopes of the beach face, surf zone, and offshore zone. The landward and seaward limits of each zone were based on breaks in slope. To obtain an accurate average by an automated procedure, each profile was fitted by a cubic spline technique. The spline representation was then used to calculate an average elevation at fixed intervals along each profile line.

17. The representative beach face slope was found to be 1:14 in 1953, 1:15 in 1963, 1:11 in 1985, and 1:10 in 1986. The representative surf zone slope was found to be 1:27 in 1953, 1:25 in 1963, 1:20 in 1985, and 1:24 in

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* References cited in this appendix are included in the references at the end of the main text, Report 1.

1986. The representative offshore slope was found to be 1:51 in 1953, 1:57 in 1963, 1:44 in 1985, and 1:49 in 1986. These results, based on four surveys, indicate that the profile has remained stable over the past three decades.

Equilibrium profile envelopes

18. The 1953 and 1985 profile data sets were compared with an estimated "equilibrium profile envelope" to a depth of 20 ft to determine if the existing profile is in equilibrium or if it is in a state of sediment deficiency or sediment excess. These plots are given in Figures D27 through D36 and D37 through D46, respectively. Note that in most cases the existing profile is within the equilibrium envelope, but very near the steep side of the envelope. The mildest equilibrium profile comprising the envelope was calculated using a representative grain size equal to the average grain size minus the standard deviation, whereas the steepest equilibrium profile of the envelope was based on the average grain size plus the standard deviation.

19. The equilibrium profile is an empirical representation of a coastal profile in equilibrium with hydrodynamic forces that act on it. Brunn (1954) and Dean (1977) have shown that the average nearshore beach profile is well represented by a simple two-thirds power law, in which the depth is proportional to the distance offshore raised to the two-thirds power. Part V of the main report gives further discussion of the equilibrium profile concept. The formula used for this calculation is as follows:

$$h = A\, x^{2/3} \tag{D1}$$

where

h = depth

A = a slowly increasing function of the grain size

x = distance offshore

20. Moore (1982) has provided a plot of the "A" parameter versus the grain size in millimeters (Figure 22 in main report). For profiles along the subject coast, the equilibrium profile appears to give a particularly good representation because of the absence of longshore bars in the measured profiles.

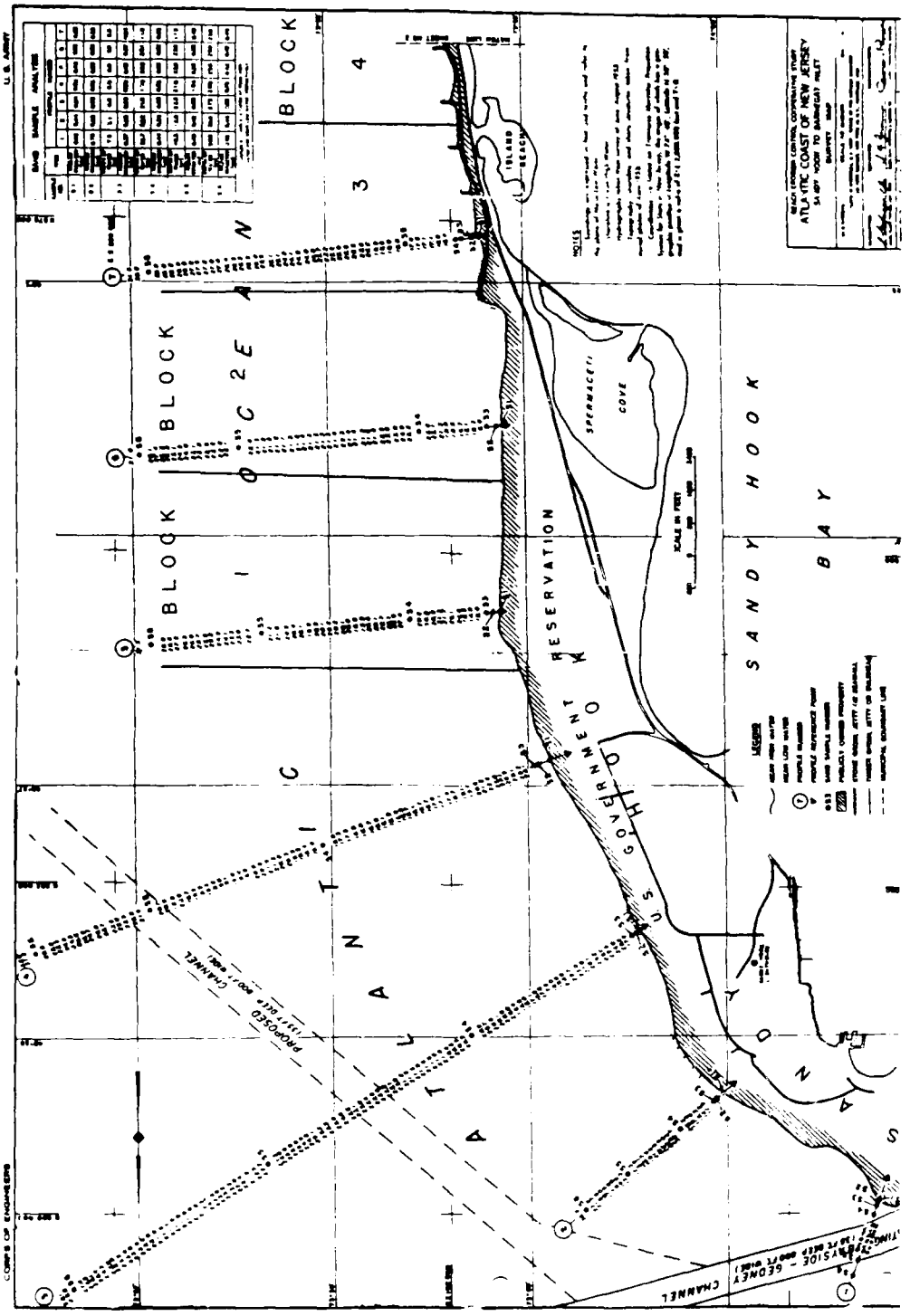


Figure D1. Location of blocks for shoreline change comparisons.
(Sheet 1 of 4)

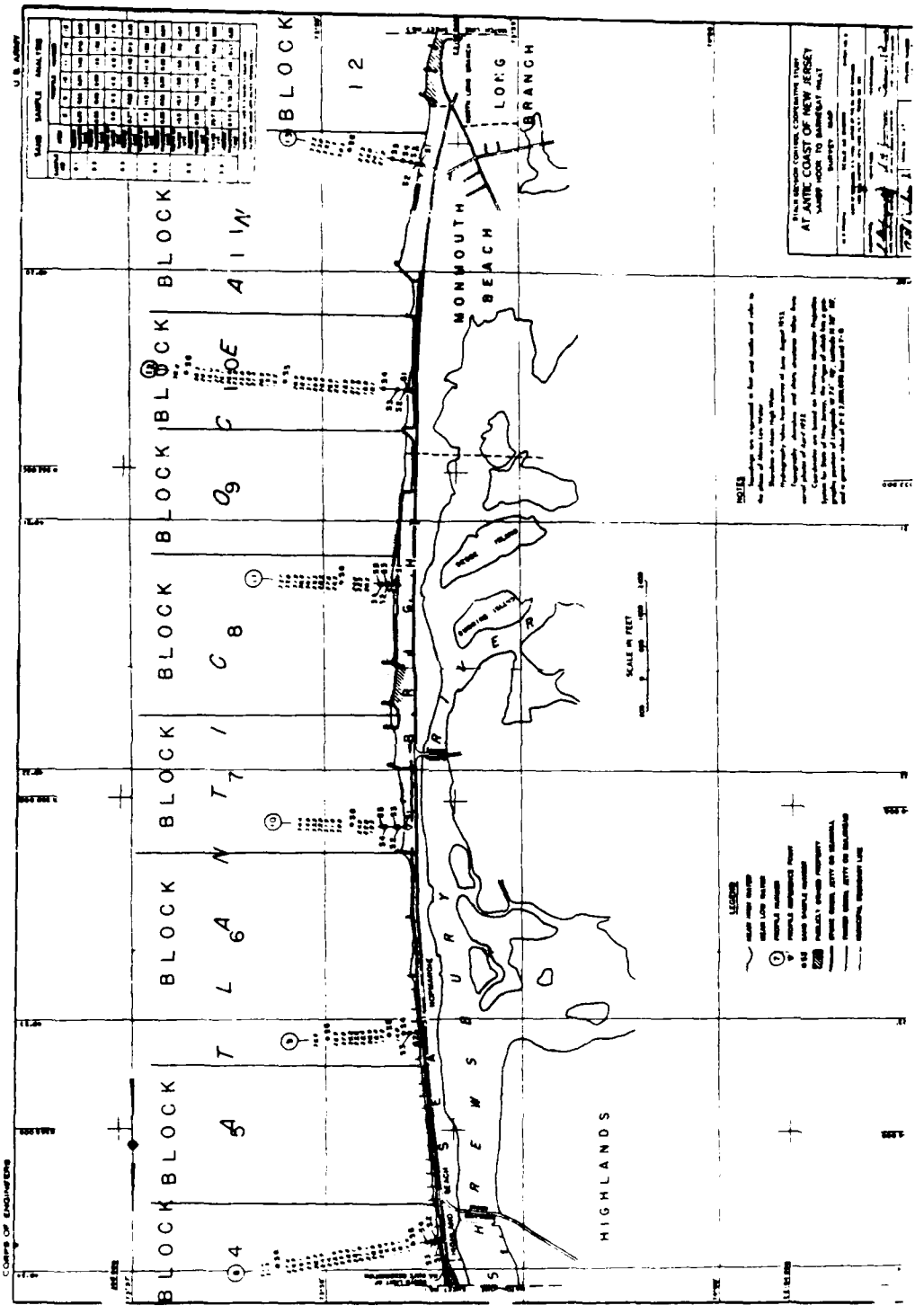


Figure D1. (Continued)

(Sheet 2 of 4)

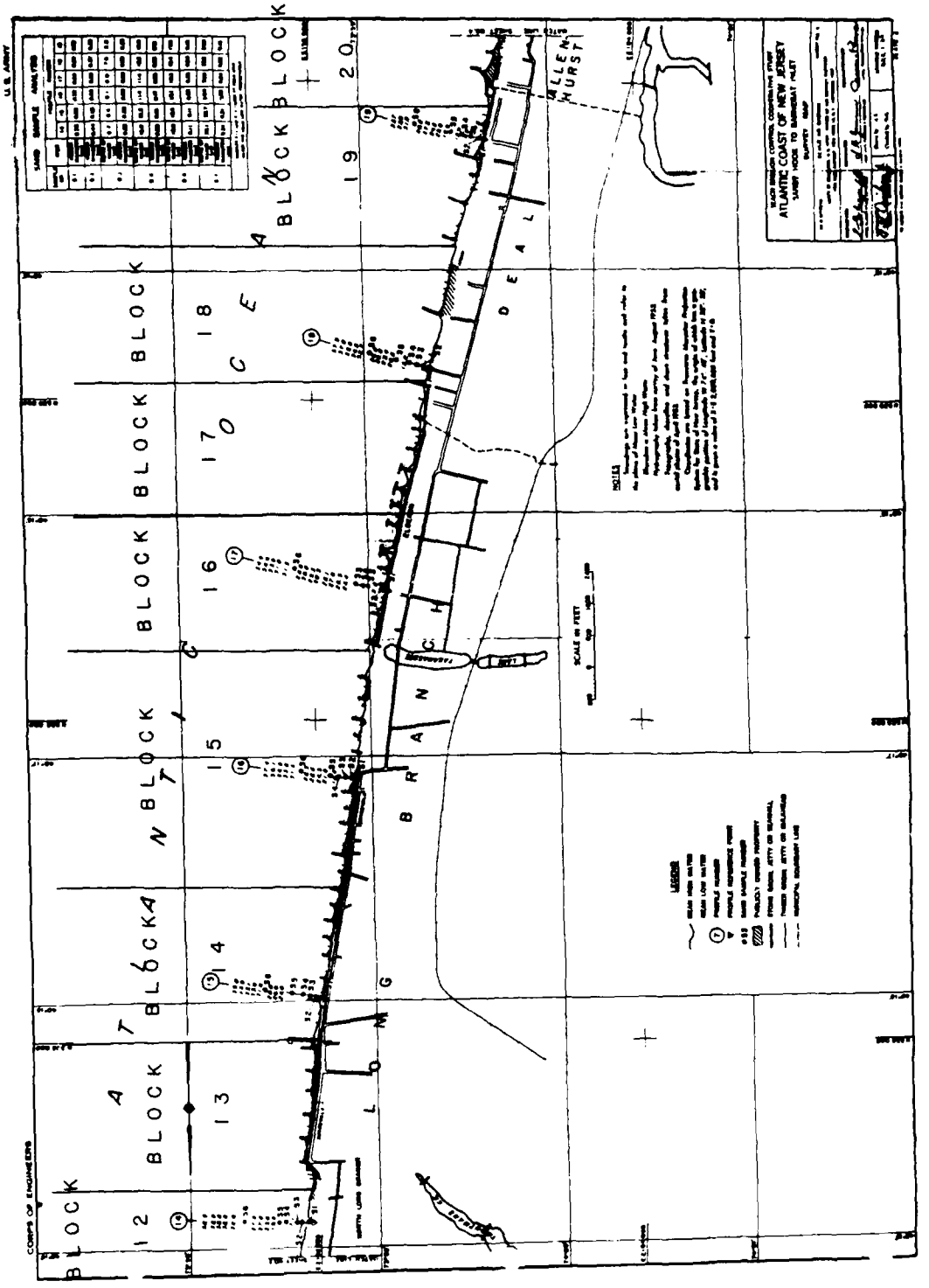


Figure D1. (Continued)

(Sheet 3 of 4)

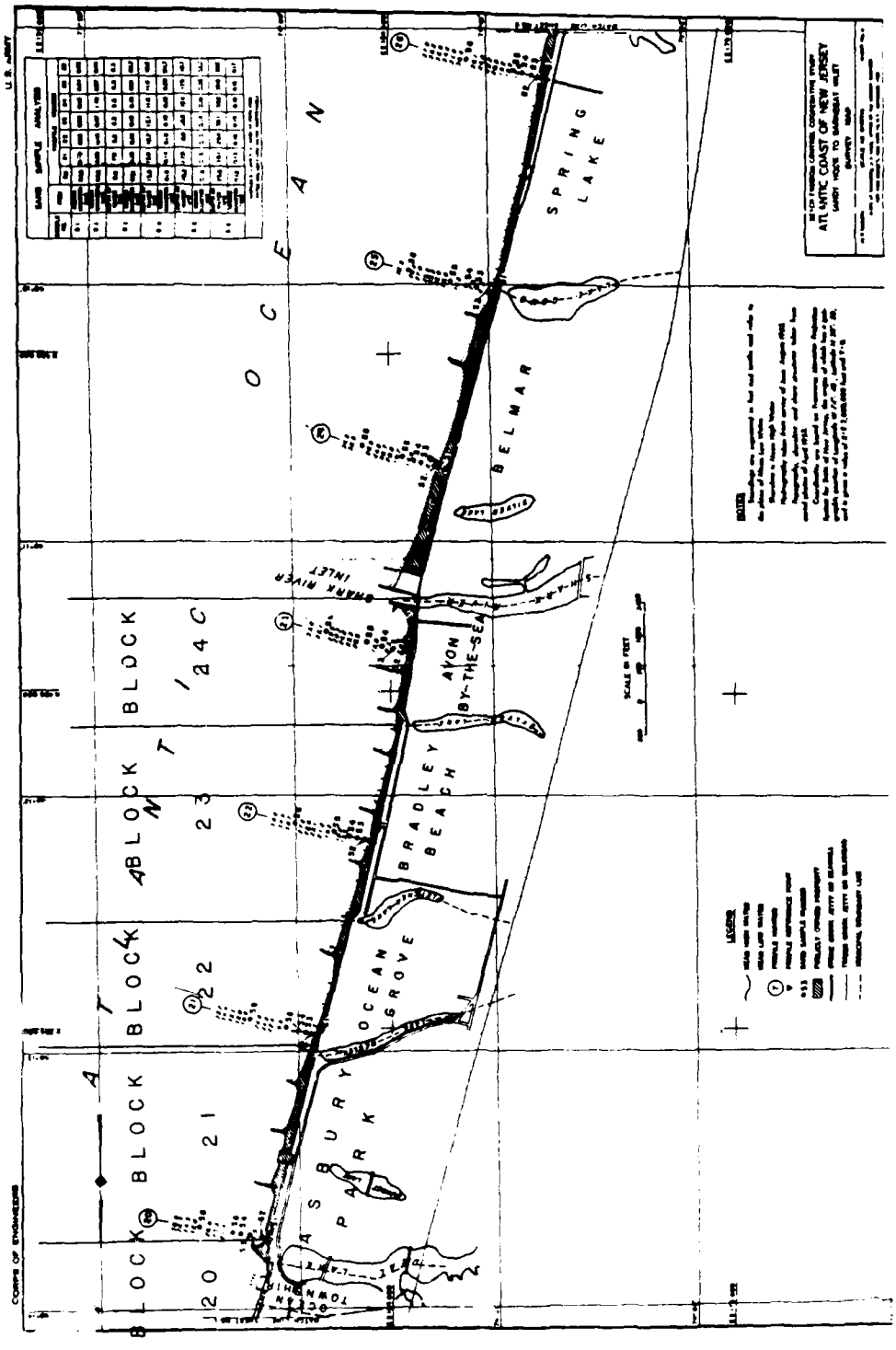


Figure D1. (Concluded)

(Sheet 4 of 4)

Table D1

Block Identification for Shoreline and Profile Change Comparisons

Block No.	Block Name	Block Length (m)	Number of Grid Cells
1	North End (Sandy Hook)	1300.0	26
2	North Point (Sandy Hook)	1300.0	26
3	South Point (Sandy Hook)	1300.0	26
4	Plum Island (Sandy Hook)	1050.0	21
5	Navesink Beach	1050.0	21
6	Normandie	1600.0	32
7	Sea Bright north	950.0	19
8	Sea Bright south	1050.0	21
9	Low Moor	1050.0	21
10	Galilee	900.0	18
11	Monmouth Beach	1200.0	24
12	North Long Branch	1200.0	24
13	Long Branch north	1350.0	27
14	Long Branch	1200.0	24
15	Long Branch south	1800.0	36
16	Elberon north	1050.0	21
17	Elberon south	1050.0	21
18	Deal north	1050.0	21
19	Deal south	1050.0	21
20	Allenhurst	1050.0	21
21	Asbury Park	1500.0	30
22	Ocean Grove	1000.0	20
23	Bradley Beach	1450.0	29
24	Avon (Shark River)	850.0	17

Table D2

Shoreline Position Data Files, Extent of Data

No.	File Name	Number of Data Points	Block Numbers With Data
1	Y1836.DAT	489	1 - 20
2	Y1848.DAT	114	1 - 4
3	Y1851.DAT	114	1 - 4
4	Y1855.DAT	114	1 - 4
5	Y1867.DAT	424	7 - 24
6	Y1899.DAT	456	6 - 24
7	Y1926.DAT	114	1 - 4
8	Y1932.DAT	570	1 - 24
9	Y1953.DAT	570	1 - 24
10	Y1961.DAT	63	2
11	Y1971.DAT	63	2
12	Y1982.DAT	63	2
13	Y1985.DAT	540	3 - 24

Table D3

Shoreline Change, Comparisons Made

Dates of Surveys Compared	Number of Blocks With Data	Notes
1836 - 1848	4	
1836 - 1855	4	
1836 - 1867	14	
1836 - 1932	20	
1836 - 1985	18	
1848 - 1851	4	171.6 m/yr accretion at Plum Is.
1851 - 1855	4	In 1848, spit was not continuous;
1855 - 1926	4	in 1851 it was continuous.
1867 - 1899	18	
1899 - 1932	19	
1926 - 1932	4	
1926 - 1953	4	
1932 - 1953	24	21 blocks show accretion.
1932 - 1985	22	
1953 - 1985	22	

Table D4

Average Rate of Shoreline Change Between 1836 and 1848 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-4.97	2.97
North Point (Sandy H.)	2	1300.0	-13.56	2.34
South Point (Sandy H.)	3	1300.0	1.00	17.96
Plum Island (Sandy H.)	4	1050.0	43.95	6.30
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: 4.72 m/yr.
Standard deviation of position rate of change: 23.26 m/yr.

Table D5

Average Rate of Shoreline Change Between 1836 and 1855 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-6.47	2.30
North Point (Sandy H.)	2	1300.0	-4.67	2.37
South Point (Sandy H.)	3	1300.0	7.59	4.94
Plum Island (Sandy H.)	4	1050.0	24.93	4.18
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: 4.36 m/yr.
Standard deviation of position rate of change: 12.60 m/yr.

Table D6

Average Rate of Shoreline Change Between 1836 and 1867 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	Data not available	
Plum Island (Sandy H.)	4	1050.0	Data not available	
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	-1.36	0.24
Sea Bright south	8	1050.0	-1.43	0.24
Low Moor	9	1050.0	-2.48	0.47
Galilee	10	900.0	-2.35	0.59
Monmouth Beach	11	1200.0	-3.52	0.47
North Long Branch	12	1200.0	-3.65	0.27
Long Branch north	13	1350.0	-3.83	0.21
Long Branch	14	1200.0	-3.27	0.32
Long Branch south	15	1800.0	-3.00	0.37
Elberon north	16	1050.0	-3.38	0.99
Elberon south	17	1050.0	-3.99	0.73
Deal north	18	1050.0	-3.17	0.42
Deal south	19	1050.0	-2.20	0.35
Allenhurst	20	1050.0	-2.01	0.41
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: -2.89 m/yr.
Standard deviation of position rate of change: 0.93 m/yr.

Table D7

Average Rate of Shoreline Change Between 1836 and 1932 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	1.30	0.50
North Point (Sandy H.)	2	1300.0	0.30	0.21
South Point (Sandy H.)	3	1300.0	0.91	0.45
Plum Island (Sandy H.)	4	1050.0	3.26	1.23
Navesink Beach	5	1050.0	-1.64	0.22
Normandie	6	1600.0	-1.62	0.22
Sea Bright north	7	950.0	-1.45	0.24
Sea Bright south	8	1050.0	-1.20	0.19
Low Moor	9	1050.0	-1.39	0.38
Galilee	10	900.0	-1.95	0.16
Monmouth Beach	11	1200.0	-1.48	0.44
North Long Branch	12	1200.0	-1.63	0.25
Long Branch north	13	1350.0	-1.65	0.40
Long Branch	14	1200.0	-1.11	0.16
Long Branch south	15	1800.0	-1.22	0.08
Elberon north	16	1050.0	-1.32	0.18
Elberon south	17	1050.0	-1.64	0.28
Deal north	18	1050.0	-1.45	0.13
Deal south	19	1050.0	-1.35	0.13
Allenhurst	20	1050.0	-1.04	0.26
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: -0.85 m/yr.
Standard deviation of position rate of change: 1.31 m/yr.

Table D8

Average Rate of Shoreline Change Between 1836 and 1985 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	0.60	0.60
Plum Island (Sandy H.)	4	1050.0	2.35	0.70
Navesink Beach	5	1050.0	-1.02	0.16
Normandie	6	1600.0	-0.94	0.12
Sea Bright north	7	950.0	-0.80	0.22
Sea Bright south	8	1050.0	-0.57	0.09
Low Moor	9	1050.0	-0.74	0.26
Galilee	10	900.0	-1.10	0.12
Monmouth Beach	11	1200.0	-0.85	0.27
North Long Branch	12	1200.0	-1.09	0.12
Long Branch north	13	1350.0	-1.11	0.20
Long Branch	14	1200.0	-0.67	0.10
Long Branch south	15	1800.0	-0.63	0.10
Elberon north	16	1050.0	-0.78	0.13
Elberon south	17	1050.0	-0.96	0.21
Deal north	18	1050.0	-0.86	0.15
Deal south	19	1050.0	-0.86	0.15
Allenhurst	20	1050.0	-0.57	0.17
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: -0.59 m/yr.
Standard deviation of position rate of change: 0.82 m/yr.

Table D9

Average Rate of Shoreline Change Between 1848 and 1851 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-29.58	11.95
North Point (Sandy H.)	2	1300.0	-52.73	8.57
South Point (Sandy H.)	3	1300.0	21.08	41.33
Plum Island (Sandy H.)	4	1050.0	171.61	32.54
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: 20.32 m/yr.
Standard deviation of position rate of change: 87.68 m/yr.

Table D10

Average Rate of Shoreline Change Between 1851 and 1855 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-8.54	8.05
North Point (Sandy H.)	2	1300.0	17.38	9.23
South Point (Sandy H.)	3	1300.0	20.24	8.06
Plum Island (Sandy H.)	4	1050.0	-10.27	5.20
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: 5.46 m/yr.
Standard deviation of position rate of change: 16.16 m/yr.

Table D11

Average Rate of Shoreline Change Between 1855 and 1926 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	3.87	0.40
North Point (Sandy H.)	2	1300.0	2.29	0.70
South Point (Sandy H.)	3	1300.0	-0.68	0.93
Plum Island (Sandy H.)	4	1050.0	-2.26	
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change 0.96 m/yr.
Standard deviation of position rate of change: 2.48 m/yr.

Table D12

Average Rate of Shoreline Change Between 1867 and 1899 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	Data not available	
Plum Island (Sandy H.)	4	1050.0	Data not available	
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	-2.79	0.35
Sea Bright south	8	1050.0	-2.02	0.38
Low Moor	9	1050.0	-1.18	0.19
Galilee	10	900.0	-1.33	0.64
Monmouth Beach	11	1200.0	-0.85	0.31
North Long Branch	12	1200.0	-0.34	0.12
Long Branch north	13	1350.0	0 29	0.27
Long Branch	14	1200.0	-0.06	0.26
Long Branch south	15	1800.0	0.04	0.22
Elberon north	16	1050.0	-0.33	0.57
Elberon south	17	1050.0	-0.68	0.23
Deal north	18	1050.0	-0.69	0.30
Deal south	19	1050.0	0.08	0.16
Allenhurst	20	1050.0	-0.03	0.36
Asbury Park	21	1500.0	-0.78	0.53
Ocean Grove	22	1000.0	0.10	0.31
Bradley Beach	23	1450.0	-0.25	0.24
Avon (Shark River)	24	850.0	-0.32	0.24

* Summary for study area as a whole.
Average shoreline position rate of change: -0.56 m/yr.
Standard deviation of position rate of change: 0.82 m/yr.

Table D13

Average Rate of Shoreline Change Between 1899 and 1932 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	Data not available	
Plum Island (Sandy H.)	4	1050.0	Data not available	
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	1.10	0.32
Sea Bright north	7	950.0	-0.25	0.59
Sea Bright south	8	1050.0	-0.19	0.56
Low Moor	9	1050.0	-0.59	0.83
Galilee	10	900.0	-2.17	0.46
Monmouth Beach	11	1200.0	-0.18	1.49
North Long Branch	12	1200.0	-0.98	0.72
Long Branch north	13	1350.0	-1.48	1.21
Long Branch	14	1200.0	-0.09	0.58
Long Branch south	15	1800.0	-0.77	0.17
Elberon north	16	1050.0	-0.33	0.20
Elberon south	17	1050.0	-0.36	0.25
Deal north	18	1050.0	-0.58	0.72
Deal south	19	1050.0	-1.94	0.22
Allenhurst	20	1050.0	-1.11	0.80
Asbury Park	21	1500.0	1.25	0.75
Ocean Grove	22	1000.0	0.29	0.68
Bradley Beach	23	1450.0	-1.08	0.50
Avon (Shark River)	24	850.0	-0.95	0.60

* Summary for study area as a whole.
Average shoreline position rate of change: -0.49 m/yr.
Standard deviation of position rate of change: 1.11 m/yr.

Table D14

Average Rate of Shoreline Change Between 1926 and 1932 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-4.45	2.00
North Point (Sandy H.)	2	1300.0	-7.51	2.82
South Point (Sandy H.)	3	1300.0	-1.43	1.55
Plum Island (Sandy H.)	4	1050.0	-0.08	0.54
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: -3.53 m/yr.
Standard deviation of position rate of change: 3.45 m/yr.

Table D15

Average Rate of Shoreline Change Between 1926 and 1953 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-2.93	1.33
North Point (Sandy H.)	2	1300.0	-7.00	1.71
South Point (Sandy H.)	3	1300.0	-0.01	2.90
Plum Island (Sandy H.)	4	1050.0	0.93	0.71
Navesink Beach	5	1050.0	Data not available	
Normandie	6	1600.0	Data not available	
Sea Bright north	7	950.0	Data not available	
Sea Bright south	8	1050.0	Data not available	
Low Moor	9	1050.0	Data not available	
Galilee	10	900.0	Data not available	
Monmouth Beach	11	1200.0	Data not available	
North Long Branch	12	1200.0	Data not available	
Long Branch north	13	1350.0	Data not available	
Long Branch	14	1200.0	Data not available	
Long Branch south	15	1800.0	Data not available	
Elberon north	16	1050.0	Data not available	
Elberon south	17	1050.0	Data not available	
Deal north	18	1050.0	Data not available	
Deal south	19	1050.0	Data not available	
Allenhurst	20	1050.0	Data not available	
Asbury Park	21	1500.0	Data not available	
Ocean Grove	22	1000.0	Data not available	
Bradley Beach	23	1450.0	Data not available	
Avon (Shark River)	24	850.0	Data not available	

* Summary for study area as a whole.
Average shoreline position rate of change: -2.41 m/yr.
Standard deviation of position rate of change: 3.61 m/yr.

Table D16

Average Rate of Shoreline Change Between 1932 and 1953 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	-2.49	1.74
North Point (Sandy H.)	2	1300.0	-6.85	2.07
South Point (Sandy H.)	3	1300.0	0.39	3.40
Plum Island (Sandy H.)	4	1050.0	1.22	0.90
Navesink Beach	5	1050.0	0.76	0.45
Normandie	6	1600.0	1.12	0.50
Sea Bright north	7	950.0	1.34	0.84
Sea Bright south	8	1050.0	2.74	0.94
Low Moor	9	1050.0	0.99	0.66
Galilee	10	900.0	1.51	0.65
Monmouth Beach	11	1200.0	1.15	0.61
North Long Branch	12	1200.0	1.50	0.74
Long Branch north	13	1350.0	0.07	0.60
Long Branch	14	1200.0	0.03	0.35
Long Branch south	15	1800.0	0.52	0.57
Elberon north	16	1050.0	0.80	0.91
Elberon south	17	1050.0	0.76	0.69
Deal north	18	1050.0	0.21	0.93
Deal south	19	1050.0	0.76	0.60
Allenhurst	20	1050.0	1.61	0.69
Asbury Park	21	1500.0	0.05	1.02
Ocean Grove	22	1000.0	-1.15	0.54
Bradley Beach	23	1450.0	0.11	0.73
Avon (Shark River)	24	850.0	0.16	0.60

* Summary for study area as a whole.
Average shoreline position rate of change: 0.23 m/yr.
Standard deviation of position rate of change: 2.15 m/yr.

Table D17

Average Rate of Shoreline Change Between 1932 and 1985 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	0.02	1.20
Plum Island (Sandy H.)	4	1050.0	0.70	0.52
Navesink Beach	5	1050.0	0.12	0.27
Normandie	6	1600.0	0.31	0.18
Sea Bright north	7	950.0	0.39	0.41
Sea Bright south	8	1050.0	0.58	0.38
Low Moor	9	1050.0	0.45	0.22
Galilee	10	900.0	0.44	0.24
Monmouth Beach	11	1200.0	0.28	0.21
North Long Branch	12	1200.0	-0.12	0.32
Long Branch north	13	1350.0	-0.15	0.27
Long Branch	14	1200.0	0.13	0.26
Long Branch south	15	1800.0	0.44	0.20
Elberon north	16	1050.0	0.20	0.18
Elberon south	17	1050.0	0.27	0.33
Deal north	18	1050.0	0.21	0.50
Deal south	19	1050.0	0.04	0.35
Allenhurst	20	1050.0	0.29	0.36
Asbury Park	21	1500.0	-0.06	0.56
Ocean Grove	22	1000.0	-0.22	0.27
Bradley Beach	23	1450.0	-0.18	0.35
Avon (Shark River)	24	850.0	0.03	0.26

* Summary for study area as a whole.
Average shoreline position rate of change: 0.18 m/yr.
Standard deviation of position rate of change: 0.48 m/yr.

Table D18

Average Rate of Shoreline Change Between 1953 and 1985 *

Block	Block No.	Block Length (m)	Average Shoreline Position Rate of Change (m/yr)	Standard Deviation (m/yr)
North End (Sandy H.)	1	1300.0	Data not available	
North Point (Sandy H.)	2	1300.0	Data not available	
South Point (Sandy H.)	3	1300.0	-0.22	0.78
Plum Island (Sandy H.)	4	1050.0	0.35	0.87
Navesink Beach	5	1050.0	-0.31	0.61
Normandie	6	1600.0	-0.22	0.35
Sea Bright north	7	950.0	-0.23	0.64
Sea Bright south	8	1050.0	-0.84	0.36
Low Moor	9	1050.0	0.10	0.44
Galilee	10	900.0	-0.26	0.57
Monmouth Beach	11	1200.0	-0.28	0.59
North Long Branch	12	1200.0	-1.18	0.56
Long Branch north	13	1350.0	-0.29	0.56
Long Branch	14	1200.0	0.19	0.45
Long Branch south	15	1800.0	0.39	0.39
Elberon north	16	1050.0	-0.20	0.35
Elberon south	17	1050.0	-0.05	0.32
Deal north	18	1050.0	0.22	0.37
Deal south	19	1050.0	-0.44	0.48
Allenhurst	20	1050.0	-0.58	0.76
Asbury Park	21	1500.0	-0.14	0.93
Ocean Grove	22	1000.0	0.39	0.40
Bradley Beach	23	1450.0	-0.36	0.34
Avon (Shark River)	24	850.0	-0.05	0.44

* Summary for study area as a whole.
Average shoreline position rate of change: -0.17 m/yr.
Standard deviation of position rate of change: 0.66 m/yr.

Table D19

Profile and Sediment Data

Block/Profile No.	Block Name	1953 Depth (ft. MLW)	1953 Grain Size (mm)	1953 Avg. (mm)	1953 S.D.+	1985 Depth (ft. MLW)	1985 Grain Size (mm)	1985 Avg. (mm)	1985 S.D.+
1 / 5	North End (Sandy Hook)	HWL	0.46	0.35	0.09				
		LWL	0.30						
		-6.0	0.42			Data not available			
		-28.0	0.23						
		-22.0	0.26						
		-29.5	0.42						
2 / 6	North Point (Sandy Hook)	HWL	0.32	0.35	0.10				
		LWL	0.53						
		-5.9	0.36			Data not available			
		-25.1	0.22						
		-22.0	0.42						
		-29.8	0.46						
3 / 7	South Point (Sandy Hook)	HWL	0.25	0.32	0.09				
		LWL	0.35						
		-5.5	0.24			Data not available			
		-11.0	0.22						
		-17.9	0.42						
		-29.9	0.46						
4 / 8	Plum Island	HWL	0.25	0.37	0.13	6.0	0.29	0.27	0.12
		LWL	0.56			0.0	0.22		
		-5.0	0.23			-6.0	0.18		
		-7.5	0.26			-12.0	0.13		
		-16.5	0.50			-18.0	0.19		
		-29.7	0.44			-24.0	0.41		
						-30.0	0.49		
5 / none	Navesink Beach								
6 / 9	Normandie	HWL	0.26	0.35	0.08	-18.0	0.24	0.60	0.34
		LWL	0.48			-24.0	0.50		
		-6.5	0.23			-30.0	1.05		
		-11.5	0.35						
		-16.7	0.38						
		-30.5	0.38						
7 / 10	Sea Bright north	HWL	0.24	0.36	0.11	7.0	0.45	0.25	0.10
		LWL	0.54			0.0	0.31		
		-4.5	0.22			-6.0	0.27		
		-12.0	0.38			-12.0	0.19		
		-15.0	0.43			-18.0	0.19		
		-27.8	0.35			-24.0	0.14		
						-30.0	0.18		

(Continued)

Table D19 (Continued)

Block/Profile No.	Block Name	1953 Depth (ft. MLW)	1953 Grain Size (mm)	1953 Avg. (mm)	1953 S.D.+	1985 Depth (ft. MLW)	1985 Grain Size (mm)	1985 Avg. (mm)	1985 S.D.+
8 / 11	Sea Bright south	HWL	0.40	0.62	0.34	6.0	0.30	0.28	0.12
		LWL	1.35			0.0	0.23		
		-6.0	0.42			-6.0	0.20		
		-11.5	0.53			-12.0	0.20		
		-15.0	0.65			-18.0	0.14		
		-26.7	0.35			-24.0	0.34		
						-30.0	0.53		
9 / none	Low Moor								
10 / 12	Galilee	HWL	0.40	0.45	0.33	6.0	0.18	0.39	0.31
		LWL	1.08			-12.0	0.27		
		-6.1	0.13			-18.0	0.22		
		-12.0	0.26			-24.0	0.30		
		-18.0	0.40			-30.0	1.00		
		-30.2	silt*						
11 / 13	Monmouth Beach	HWL	0.40	0.30	0.08	0.0	0.37	0.26	0.08
		LWL	0.38			-6.0	0.29		
		-7.0	0.22			-12.0	0.21		
		-12.0	0.34			-18.0	0.11		
		-18.4	0.22			-24.0	0.27		
		-30.0	0.23			-30.0	0.30		
12 / 14	N. Long Branch	HWL	0.33	0.34	0.14	6.0	0.31	0.34	0.24
		LWL	0.44			0.0	0.93		
		-6.7	0.55			-6.0	0.23		
		-12.0	0.38			-12.0	0.26		
		-18.0	0.11			-18.0	0.27		
		-30.1	0.24			-24.0	0.19		
						-30.0	0.21		
13 / none	Long Branch north								
14 / 15	Long Branch	HWL	0.52	0.41	0.25	6.0	0.28	0.23	0.08
		LWL	0.85			0.0	0.31		
		-6.4	0.50			-6.0	0.27		
		-12.2	0.15			-12.0	0.21		
		-18.4	0.11			-18.0	0.11		
		-30.7	0.31			-24.0	0.10		
						-30.0	0.30		

(Continued)

Table D19 (Continued)

Block/Profile No.	Block Name	1953 Depth (ft. MLW)	1953 Grain Size (mm)	1953 Avg. (mm)	1953 S.D.+	1985 Depth (ft. MLW)	1985 Grain Size (mm)	1985 Avg. (mm)	1985 S.D.+
15 / 16	Long Branch south	HWL	0.32	0.37	0.16	6.0	0.28	0.33	0.13
		LWL	0.65			0.0	0.58		
		-6.1	0.50			-6.0	0.30		
		-11.4	0.17			-12.0	0.28		
		-18.1	0.26			-18.0	0.22		
		-30.0	0.29			-24.0	0.18		
						-30.0	0.47		
16 / 17	Elberon north	HWL	0.36	0.32	0.05	0.0	0.48	0.36	0.06
		LWL	0.38			-6.0	0.32		
		-6.0	0.28			-12.0	0.31		
		-11.4	0.33			-18.0	0.32		
		-18.6	0.35			-24.0	0.35		
		-30.0	0.24			-30.0	0.40		
17 / none	Elberon south								
18 / 18	Deal north	HWL	0.39	0.31	0.07	6.0	0.30	0.28	0.11
		LWL	0.37			0.0	0.49		
		-7.0	0.29			-6.0	0.34		
		-12.6	0.36			-12.0	0.24		
		-18.4	0.24			-18.0	0.20		
		-30.2	0.22			-24.0	0.26		
						-30.0	0.12		
19 / 19	Deal south	HWL	0.32	0.28	0.08	0.0	0.28	0.31	0.12
		LWL	0.33			-6.0	0.21		
		-5.8	0.38			-12.0	0.40		
		-12.0	0.31			-18.0	0.17		
		-17.8	0.18			-24.0	0.48		
		-29.8	0.16						
20 / none	Allenhurst								
21 / 20	Asbury Park	HWL	0.25	0.20	0.07	6.0	0.26	0.20	0.16
		LWL	0.32			0.0	1.90*		
		-6.4	0.21			-6.0	0.22		
		-13.4	0.15			-12.0	0.20		
		-18.2	0.16			-18.0	0.17		
		-29.8	0.12			-24.0	0.14		
						-30.0	0.18		

(Continued)

Table D19 (Concluded)

Block/Profile No.	Block Name	1953 Depth (ft. MLW)	1953 Grain Size (mm)	1953 Avg. (mm)	1953 S.D.+	1985 Depth (ft. MLW)	1985 Grain Size (mm)	1985 Avg. (mm)	1985 S.D.+
22 / 21	Ocean Grove	HWL	0.38	0.26	0.17	6.0	0.41	0.24	0.10
		LWL	0.59			0.0	0.31		
		-7.0	0.18			-6.0	0.18		
		-13.0	0.14			-12.0	0.17		
		-17.9	0.15			-18.0	0.11		
		-30.1	0.13			-24.0	0.17		
						-30.0	0.30		
23 / 22	Bradley Beach	HWL	0.53	0.27	0.15	6.0	0.31	0.21	0.10
		LWL	0.43			0.0	0.37		
		-5.8	0.18			-6.0	0.27		
		-12.7	0.18			-12.0	0.20		
		-18.0	0.13			-18.0	0.12		
		-29.4	0.16			-24.0	0.11		
						-30.0	0.11		
24 / 23	Avon (Shark River)	HWL	0.36	0.26	0.12	6.0	0.41	0.20	0.10
		LWL	0.47			0.0	0.20		
		-6.2	0.18			-6.0	0.22		
		-12.1	0.19			-12.0	0.15		
		-18.2	0.14			-18.0	0.11		
		-30.1	0.19			-24.0	0.10		
						-30.0	1.30*		

Notation: * ; anomalous data points were not used
; S.D. denotes the standard deviation in grain size

(Sheet 4 of 4)

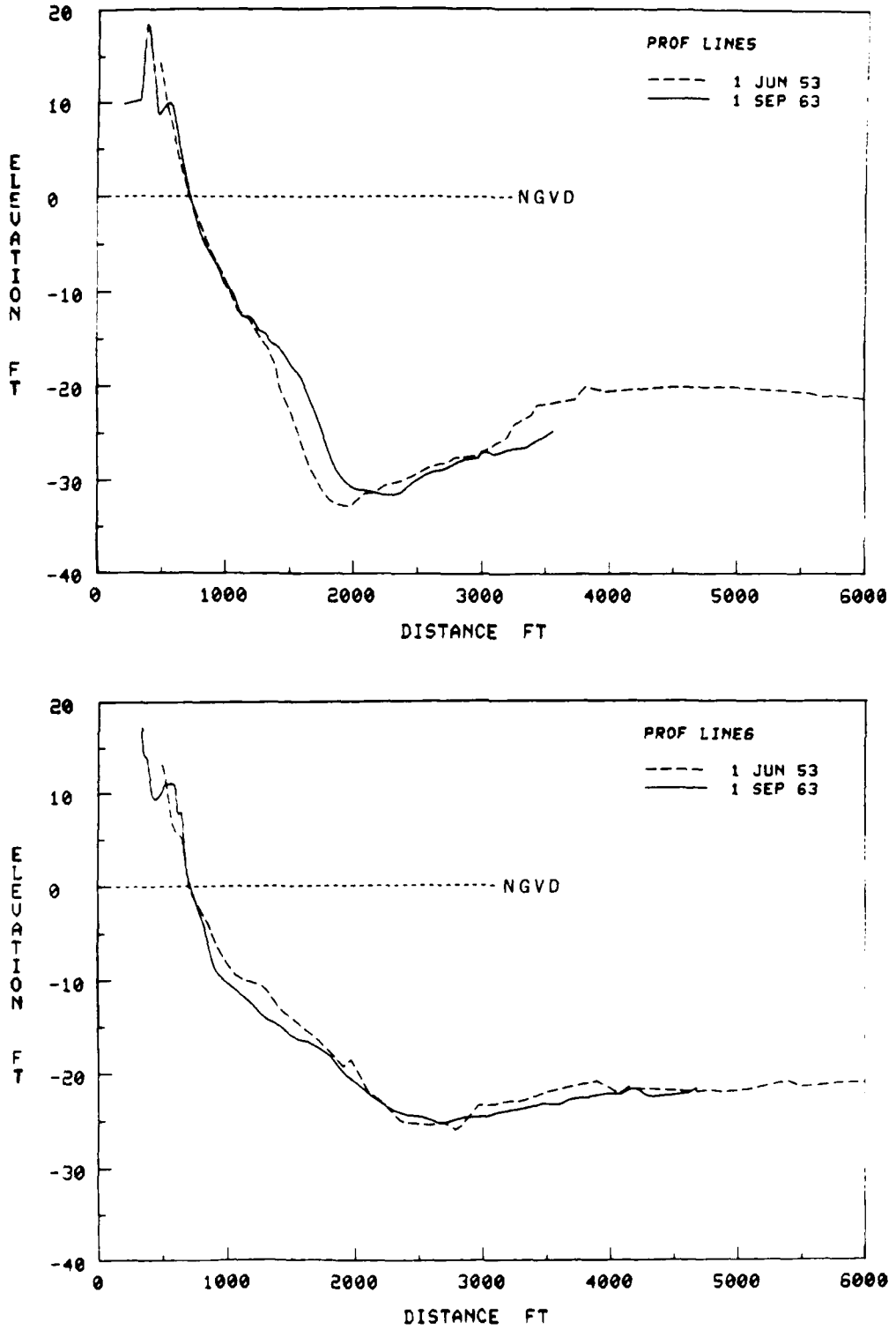
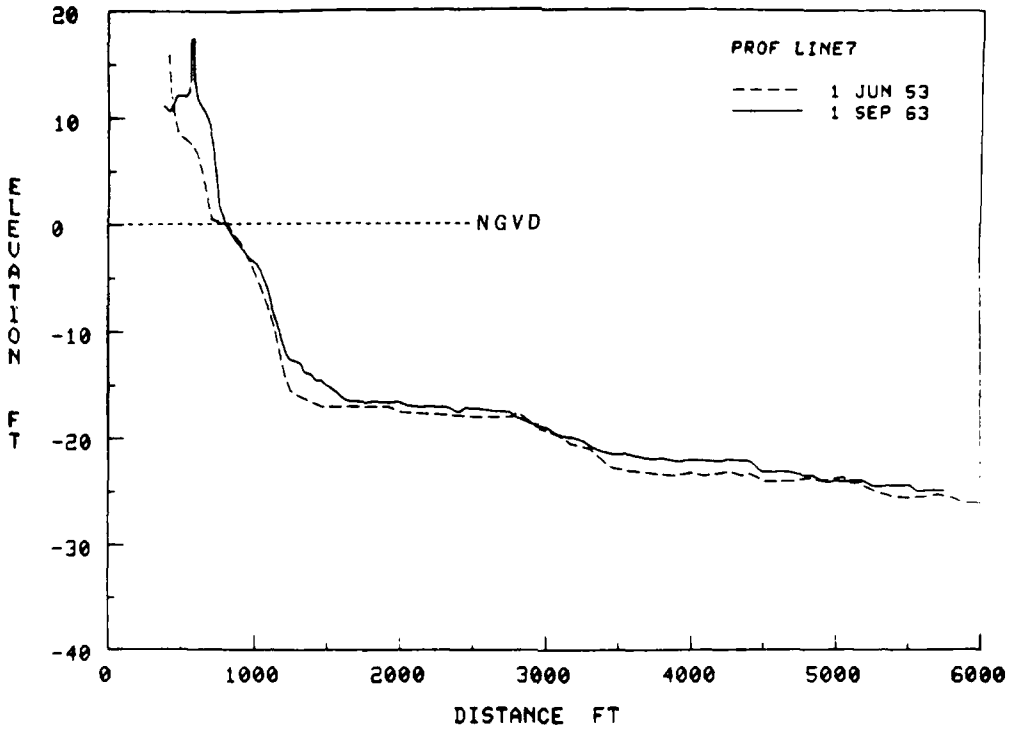


Figure D2. Profile comparisons 1953-1963, lines 5 and 6



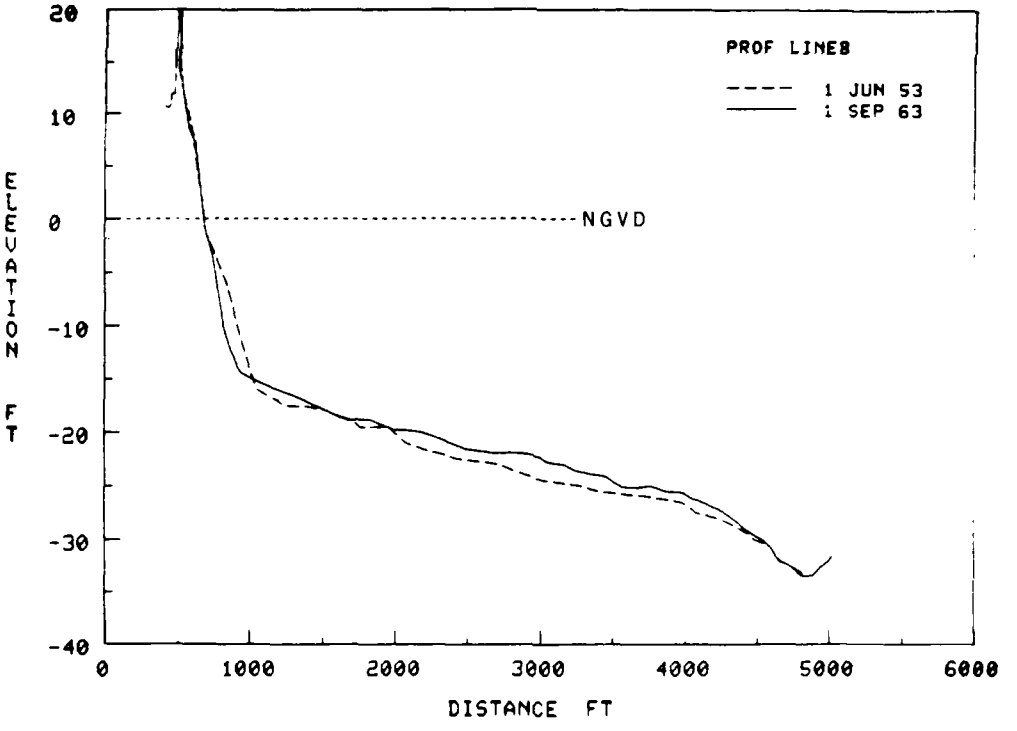
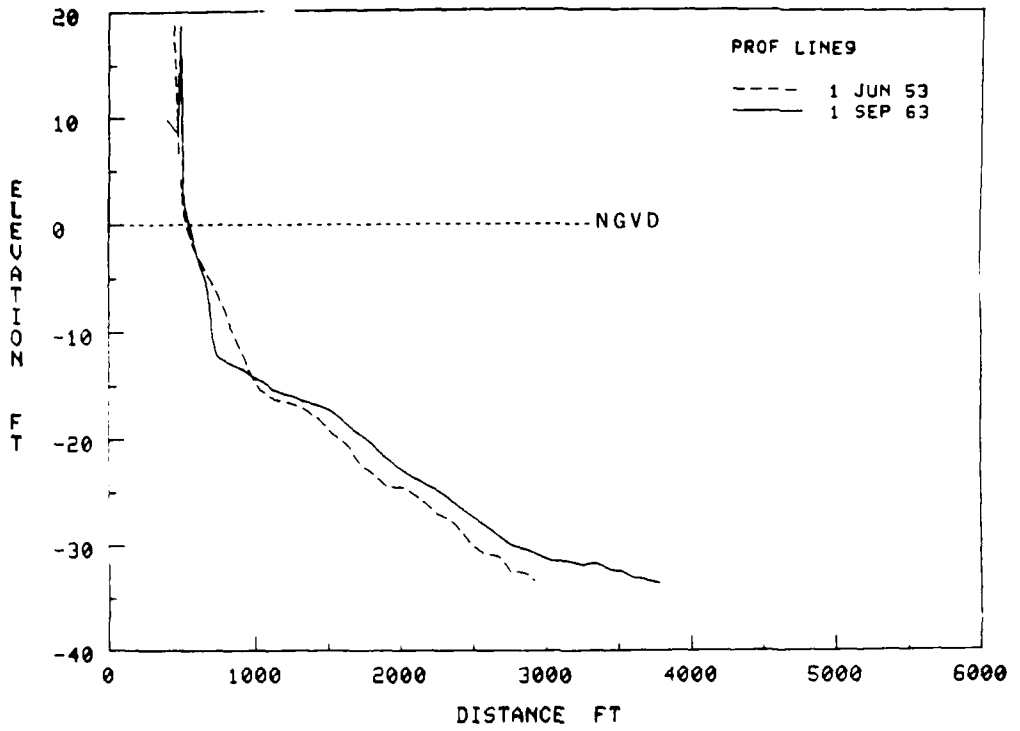


Figure D3. Profile comparisons 1953-1963, lines 7 and 8



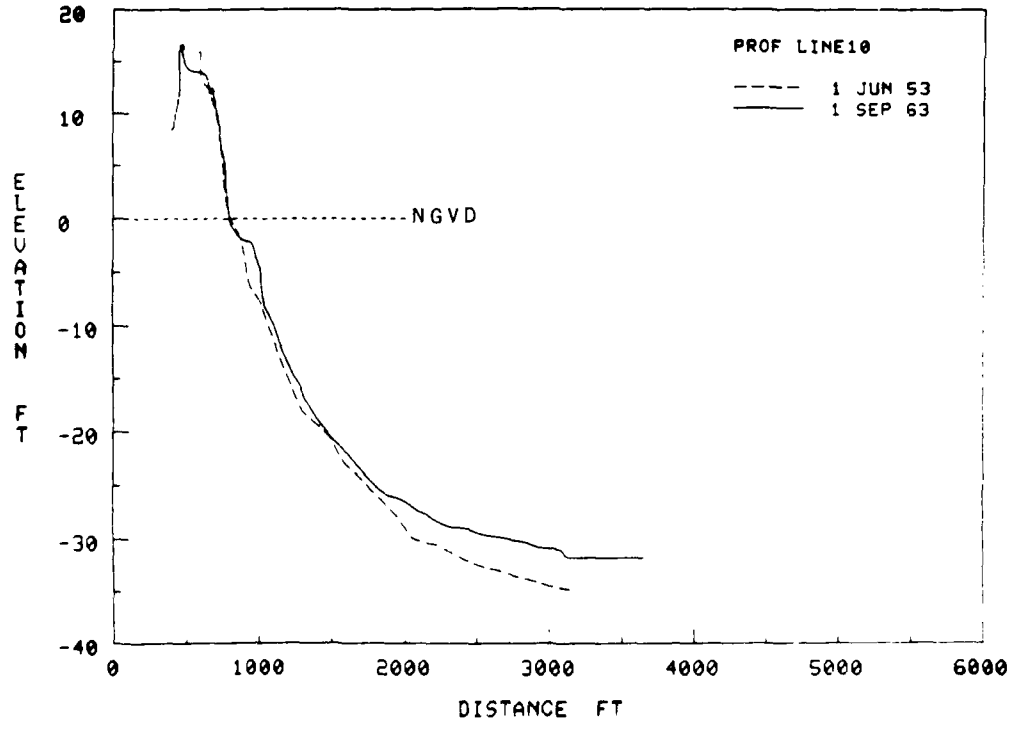
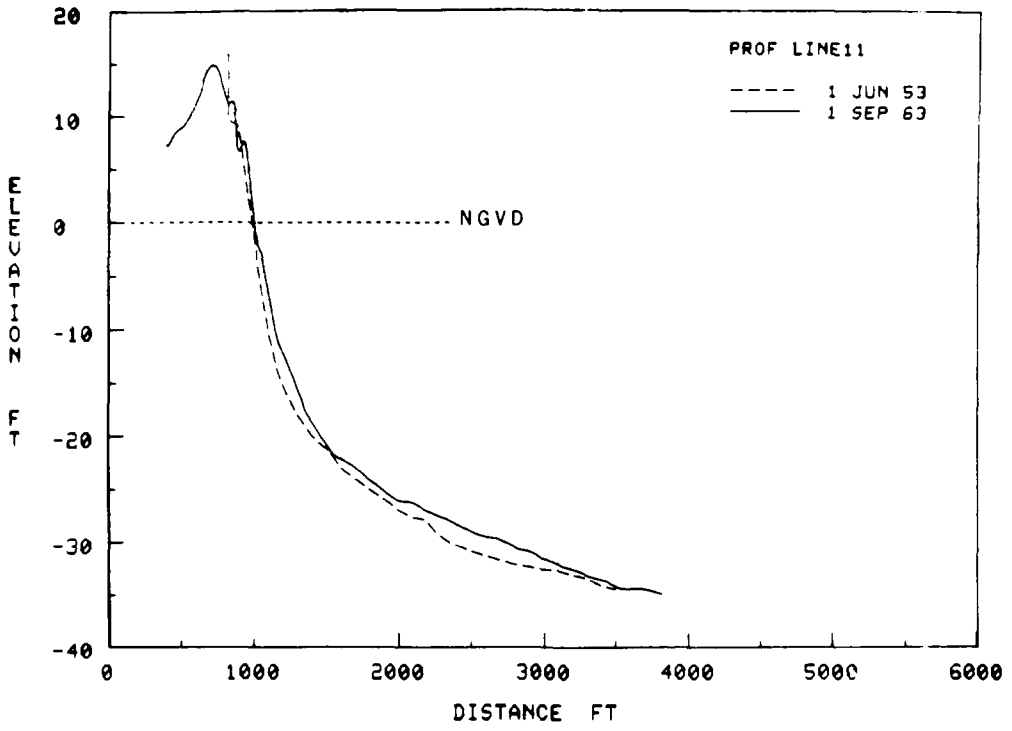


Figure D4. Profile comparisons 1953-1963, lines 9 and 10



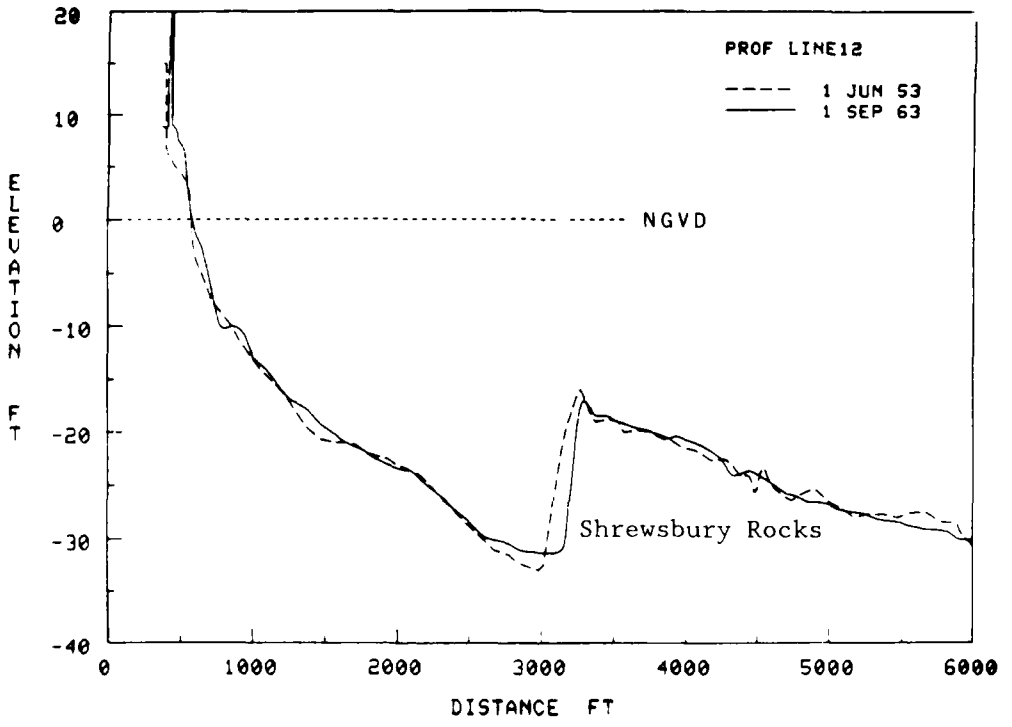
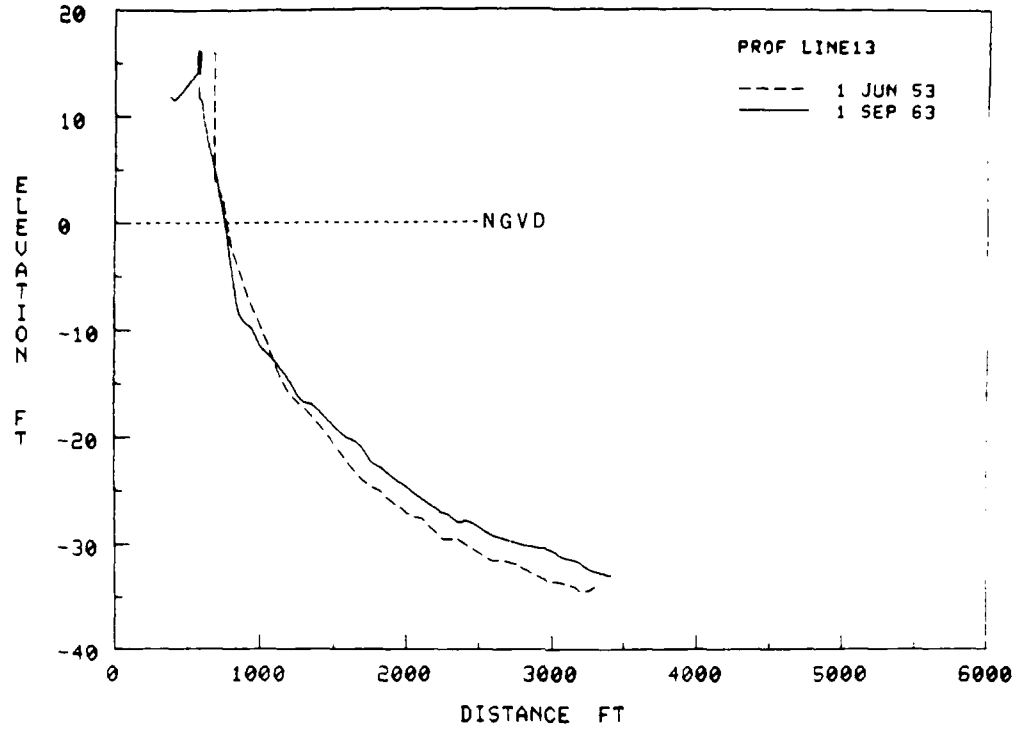


Figure D5. Profile comparisons 1953-1963, lines 11 and 12



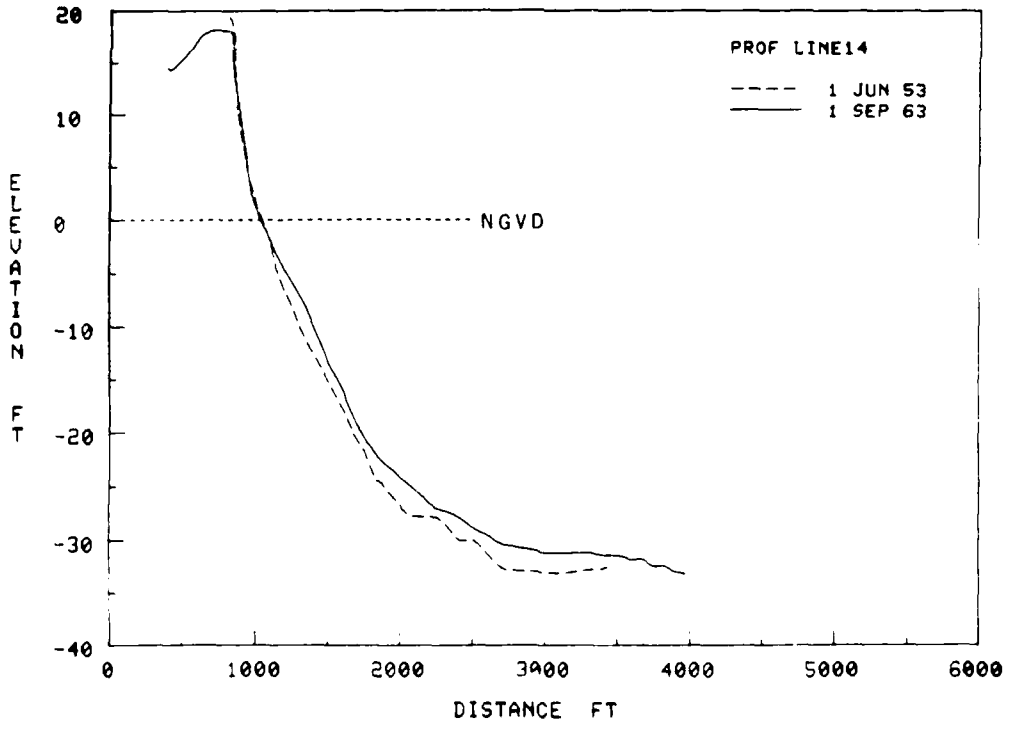


Figure D6. Profile comparisons 1953-1963, lines 13 and 14

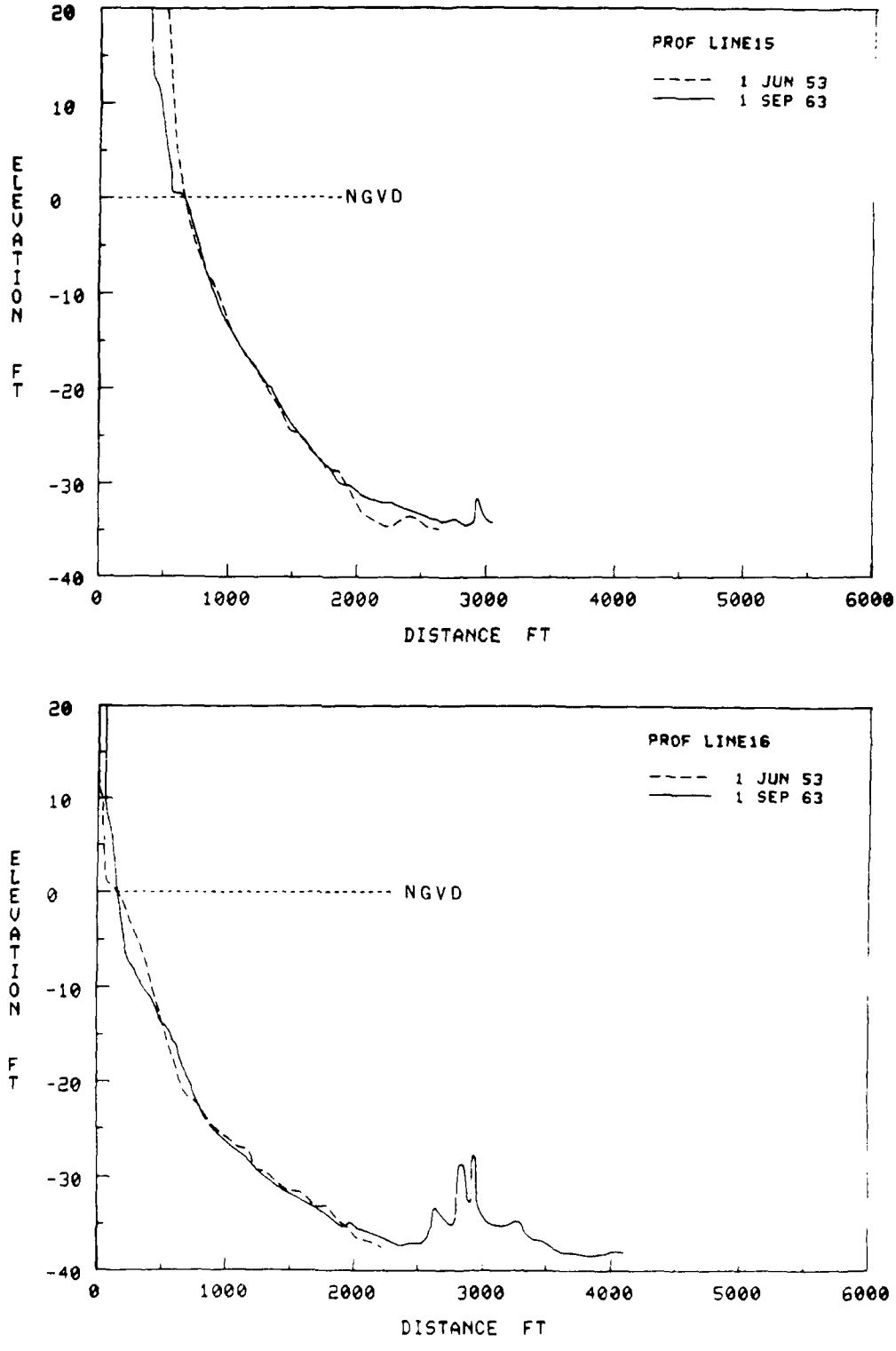
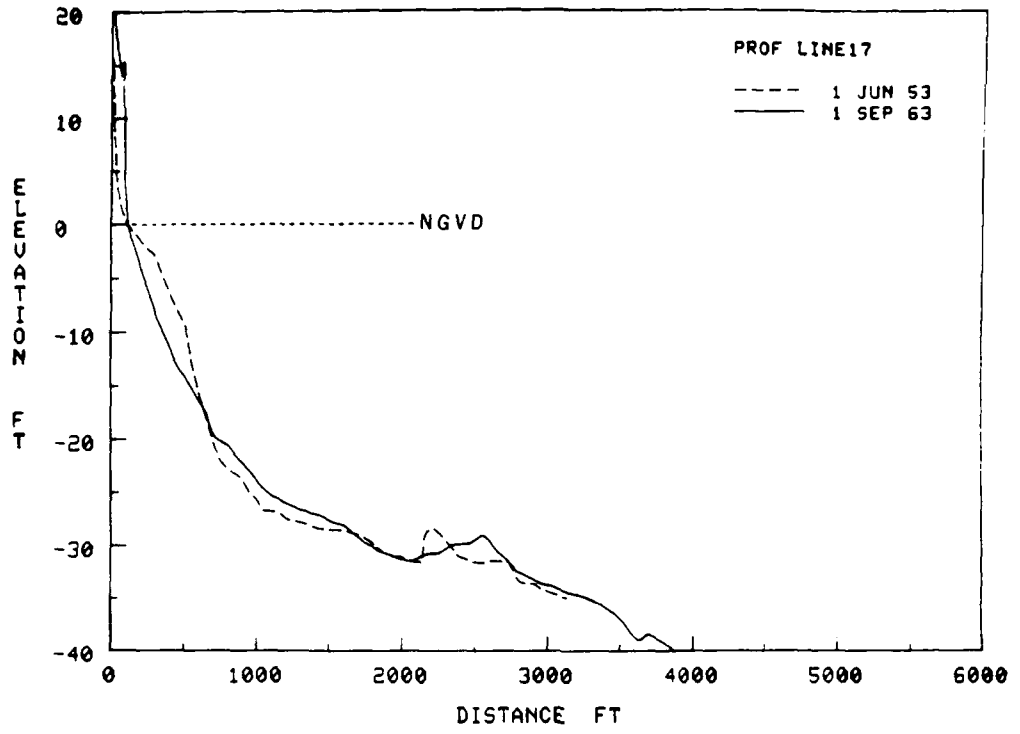


Figure D7. Profile comparisons 1953-1963, lines 15 and 16



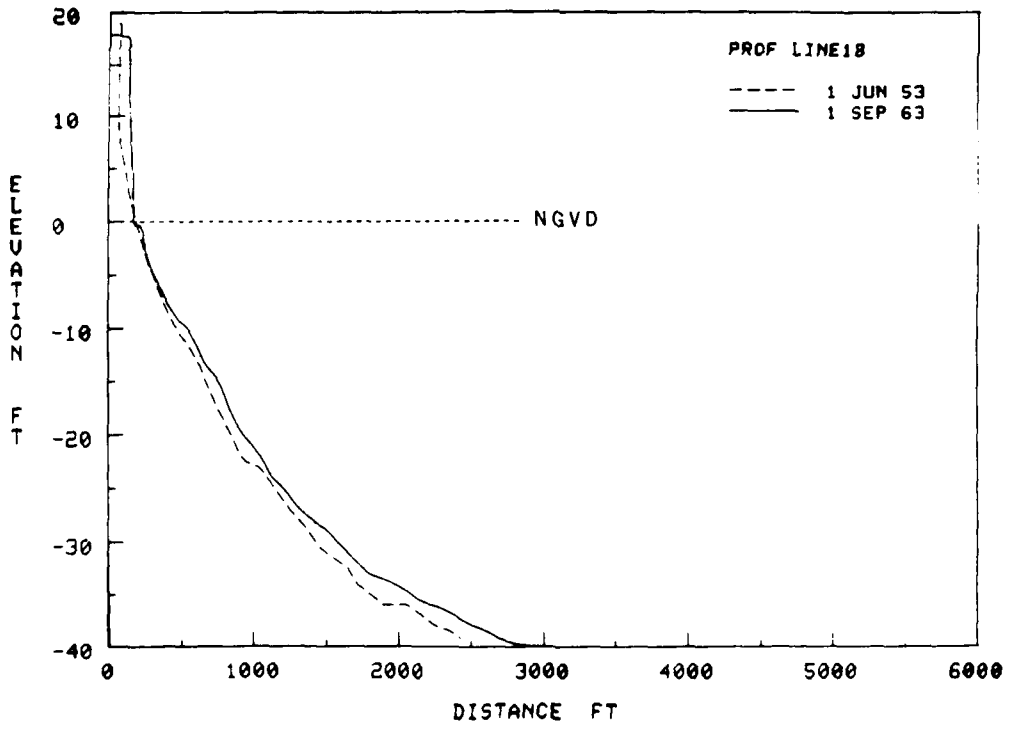
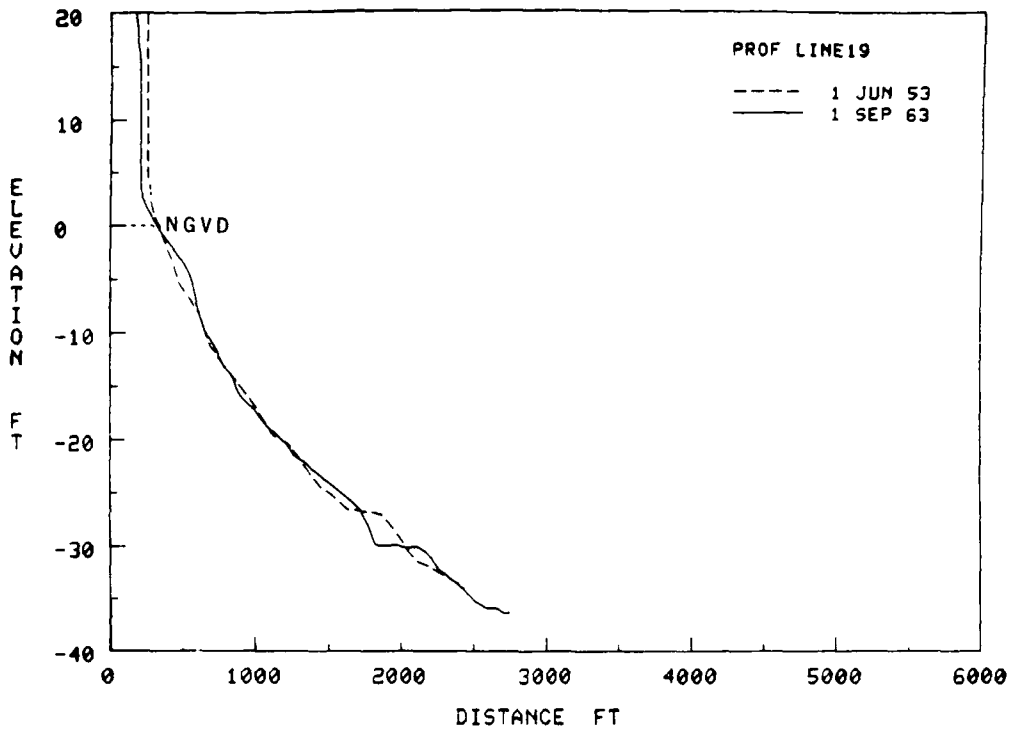


Figure D8. Profile comparisons 1953-1963, lines 17 and 18



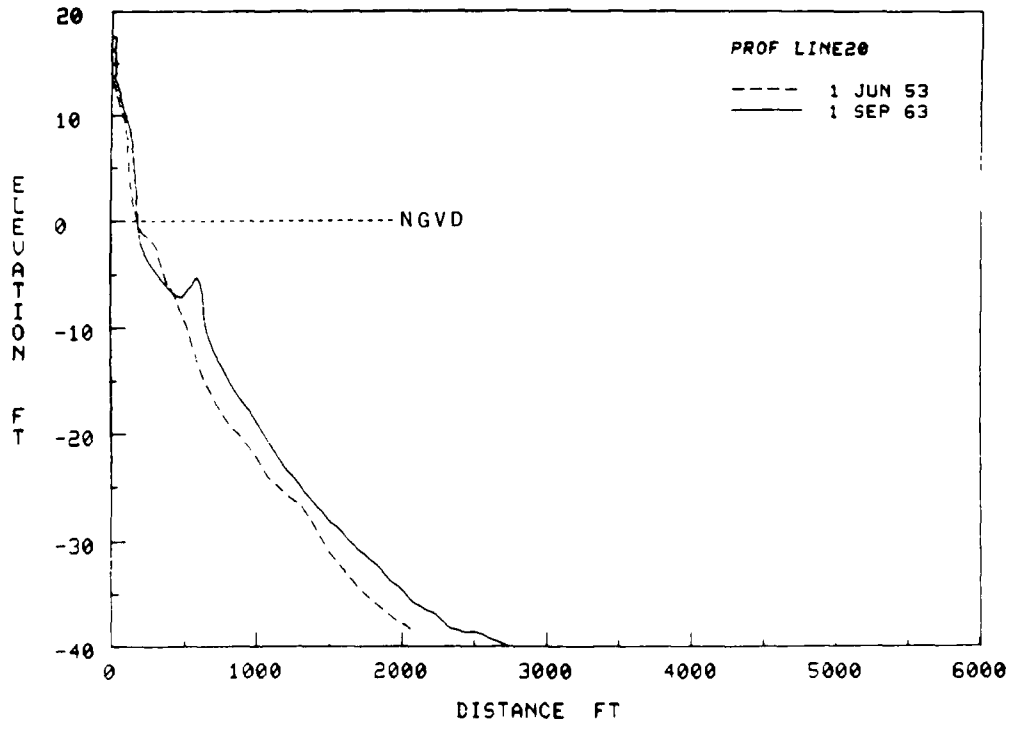
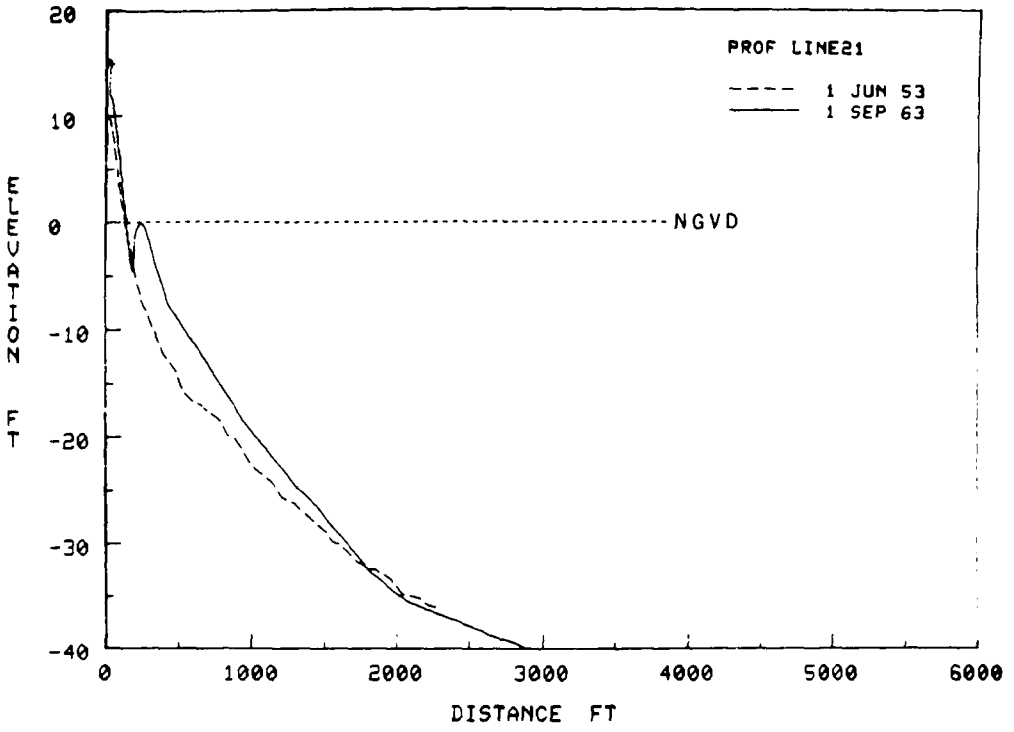


Figure D9. Profile comparisons 1953-1963, lines 19 and 20



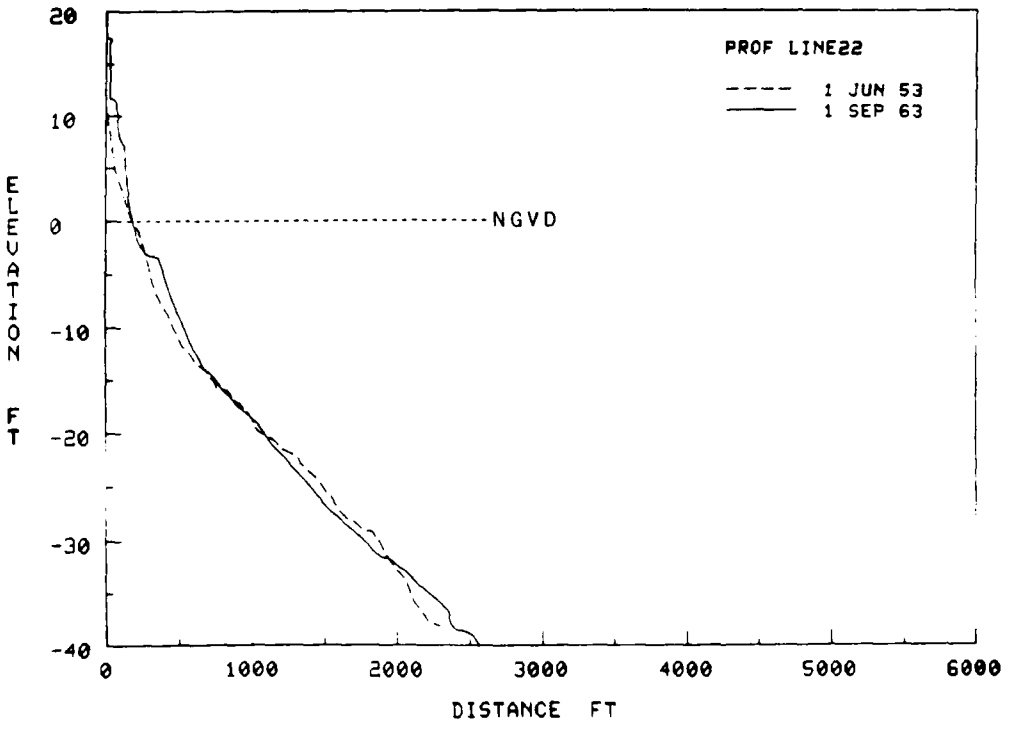


Figure D10. Profile comparisons 1953-1963, lines 21 and 22

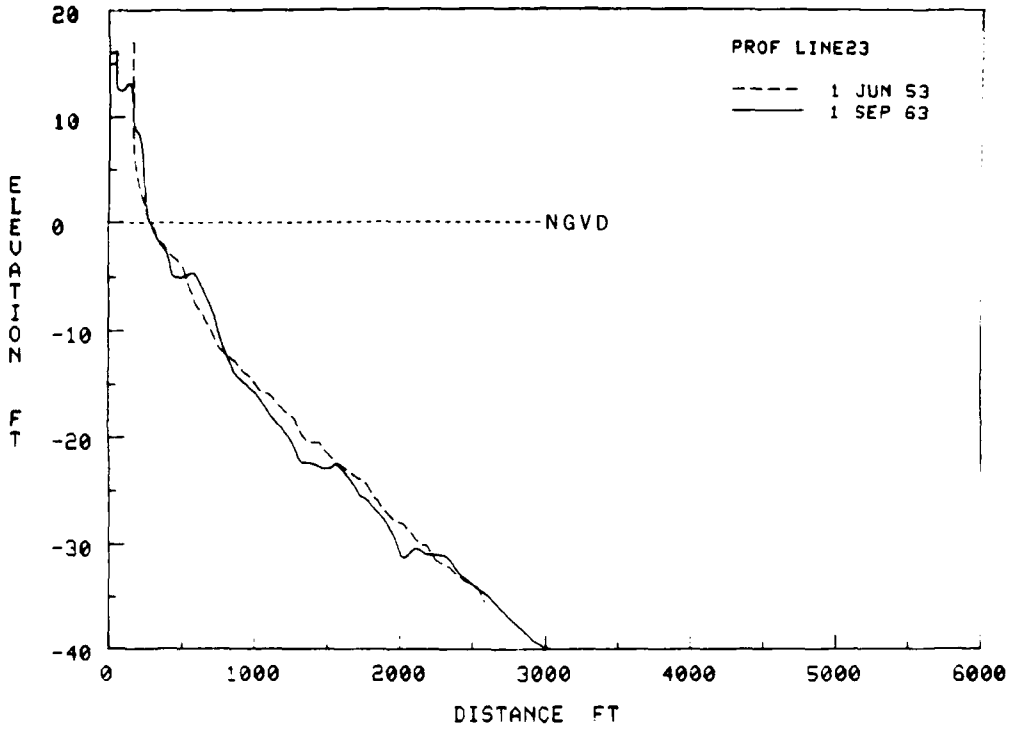
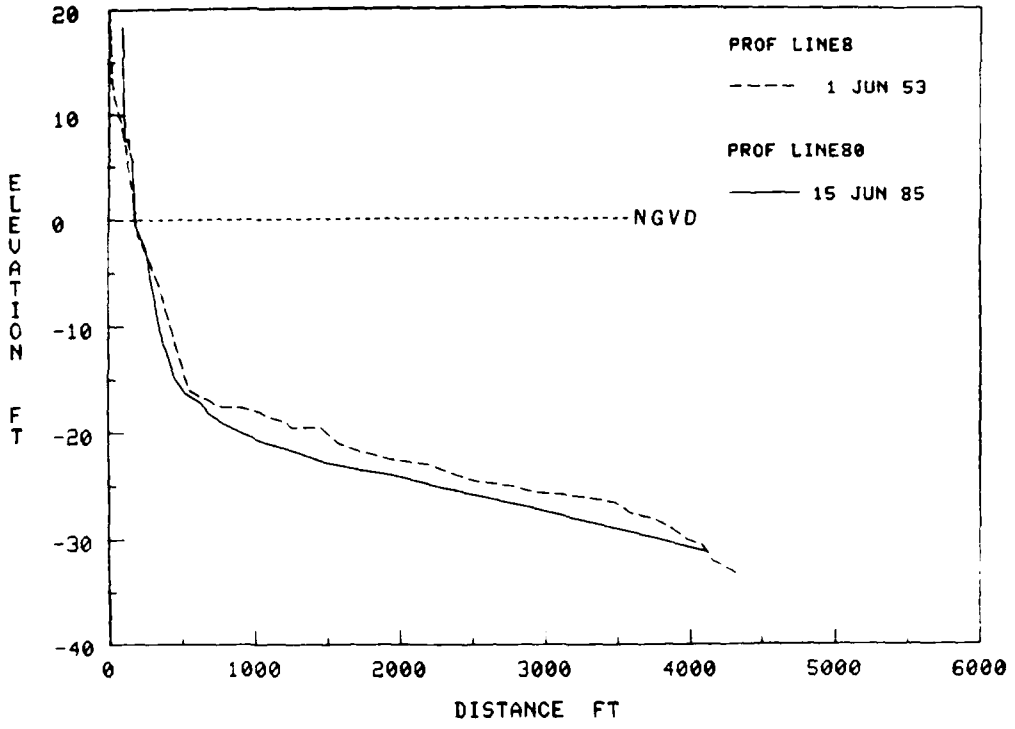


Figure D11. Profile comparisons 1953-1963, line 23



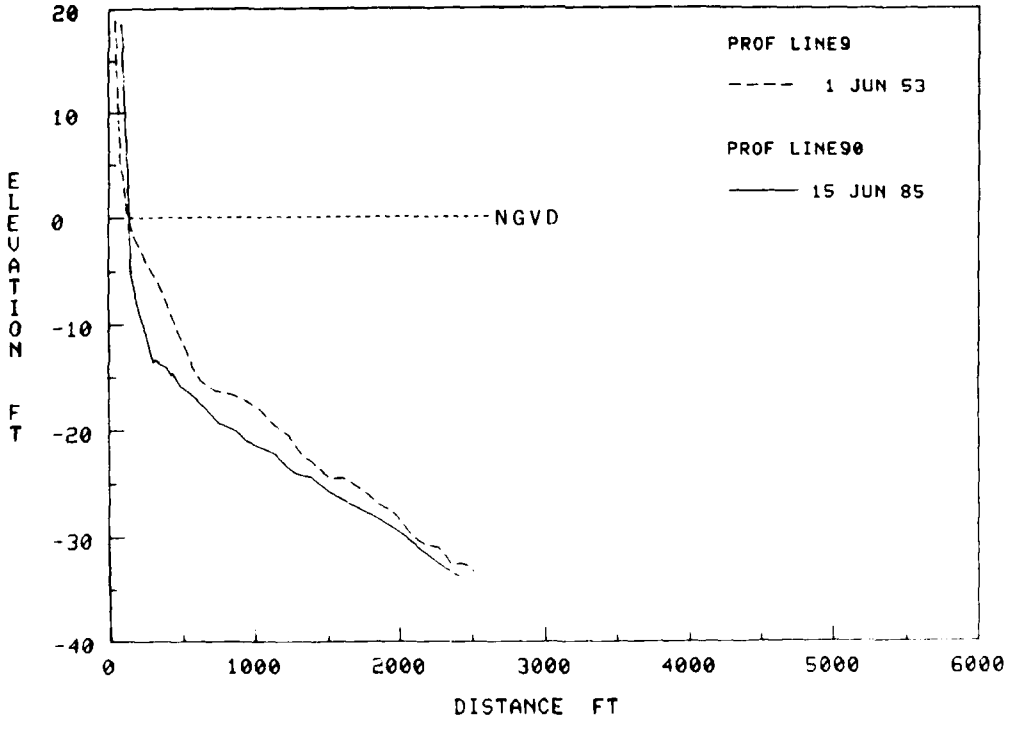
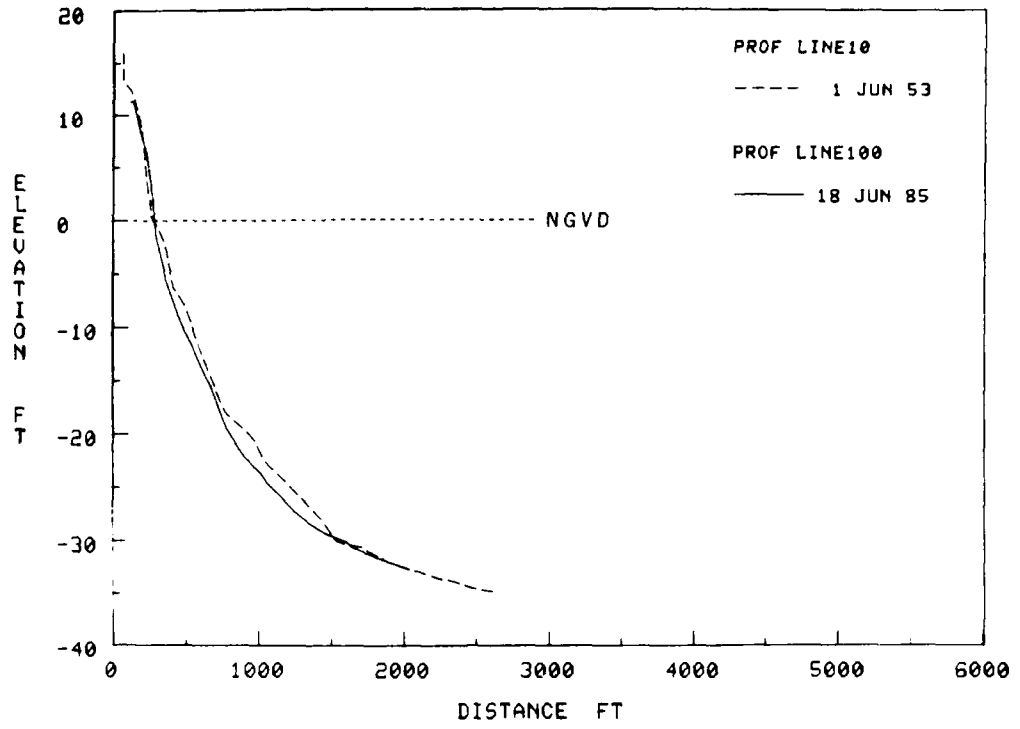


Figure D12. Profile comparisons 1953-1985, lines 8 and 9 (80 and 90)



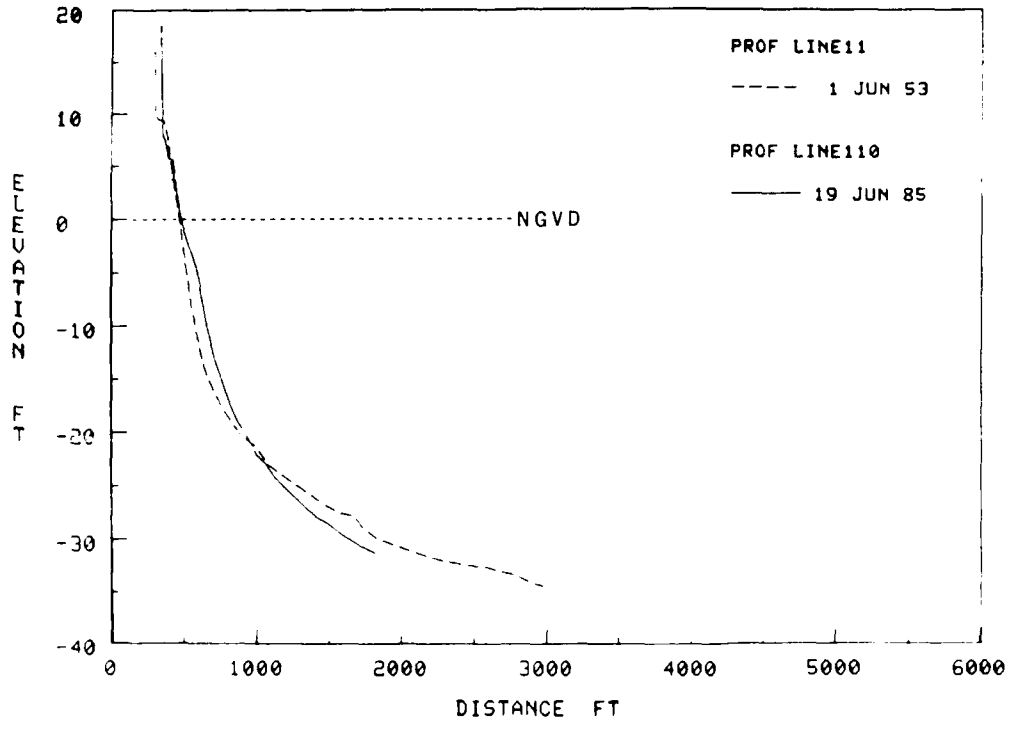
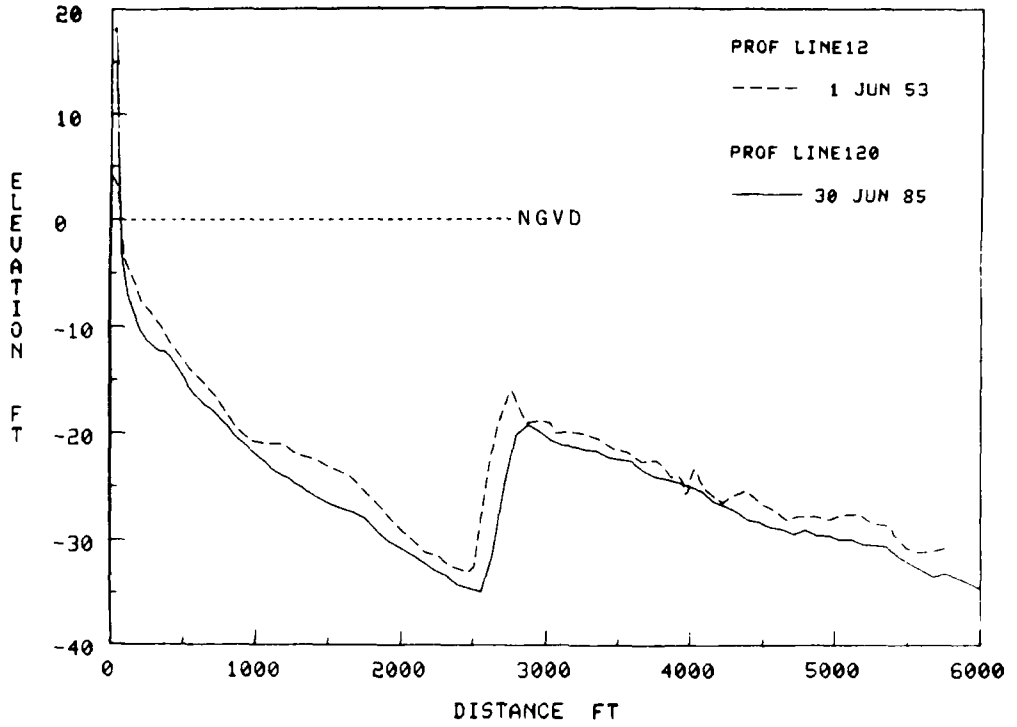


Figure D13. Profile comparisons 1953-1985, lines 10 and 11 (100 and 110)



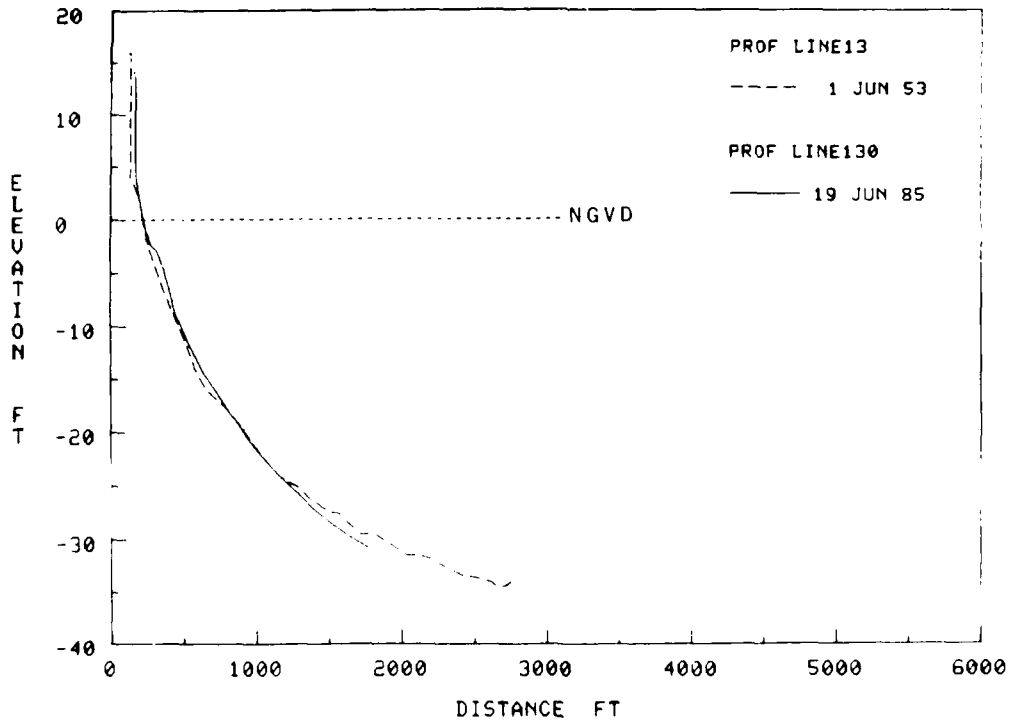
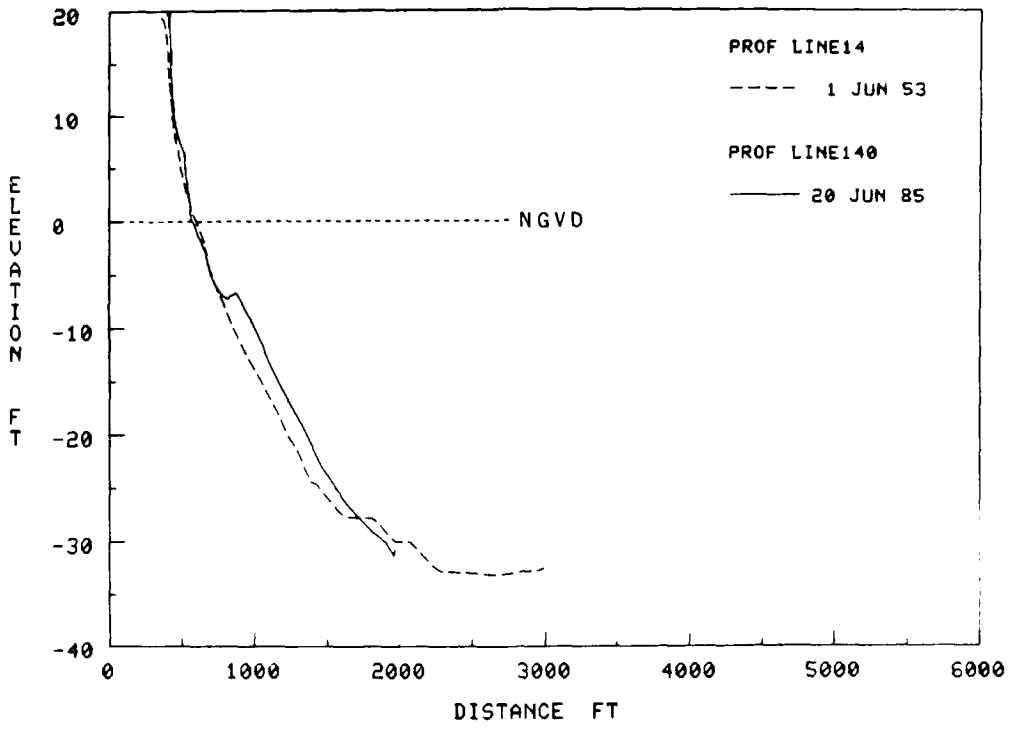


Figure D14. Profile comparisons 1953-1985, lines 12 and 13 (120 and 130)



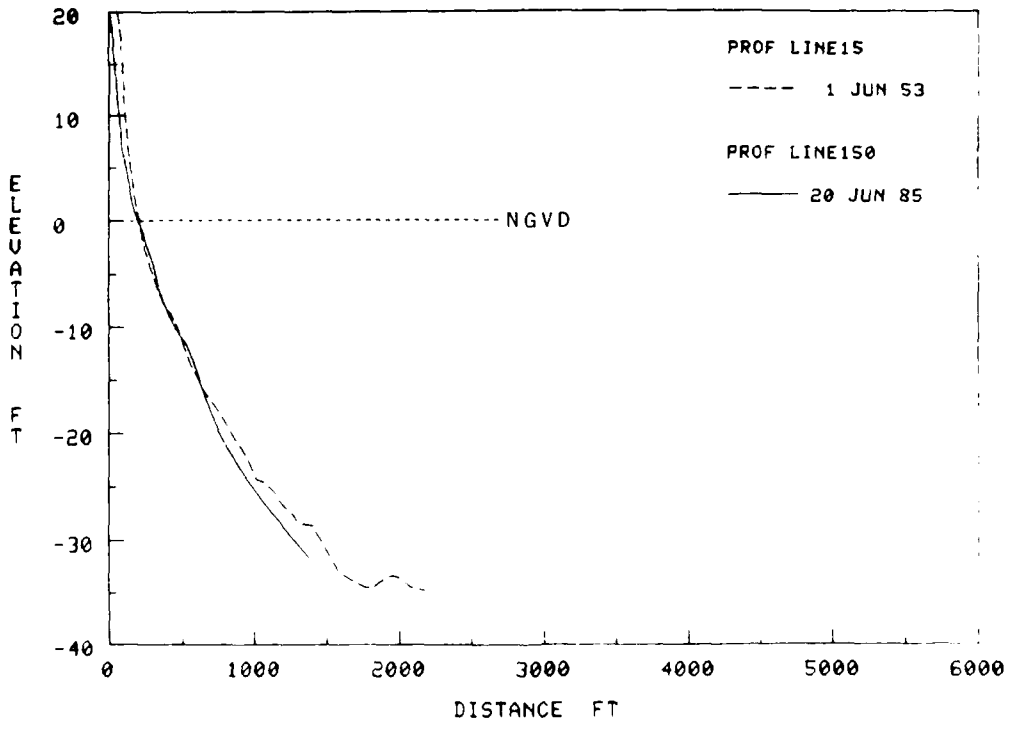
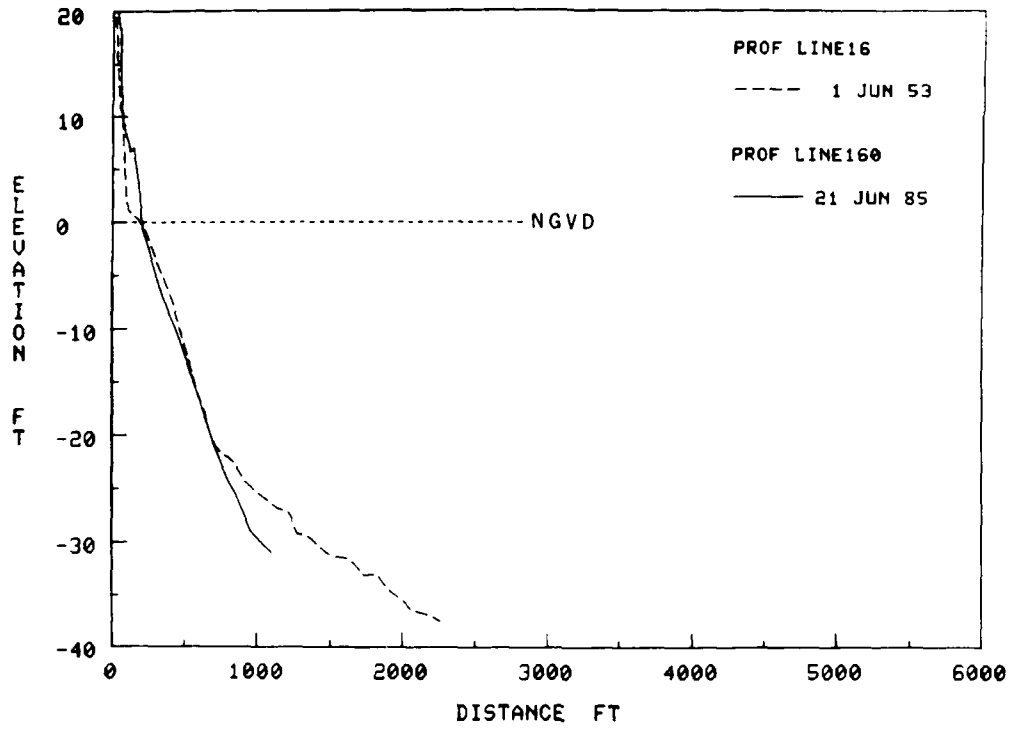


Figure D15. Profile comparisons 1953-1985, lines 14 and 15 (140 and 150)



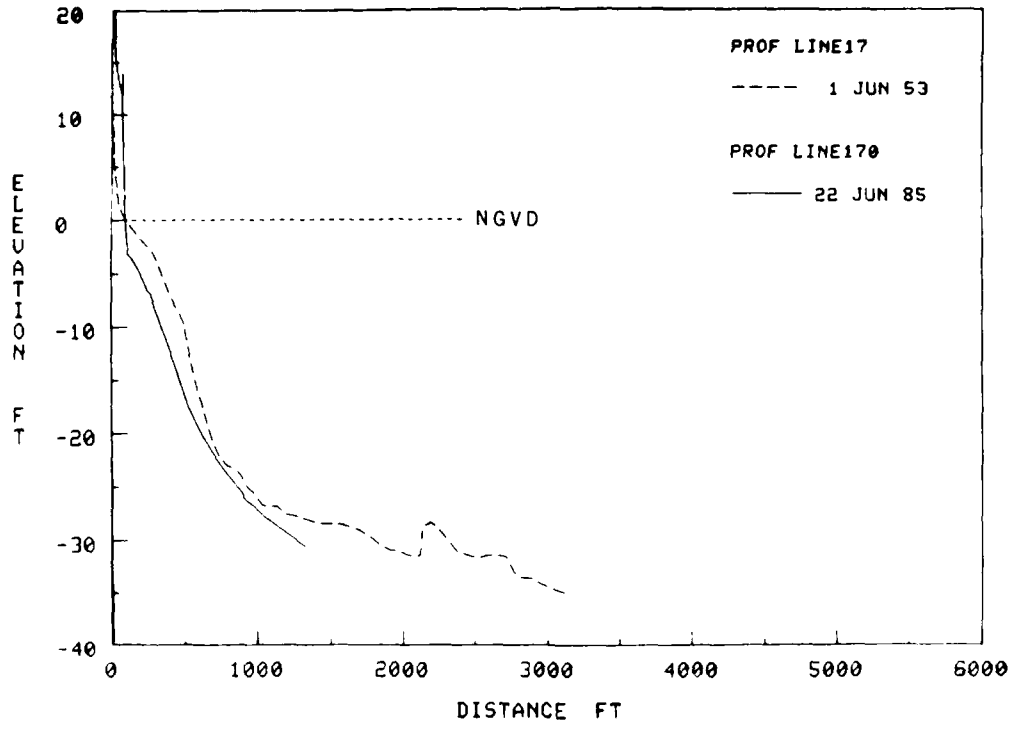
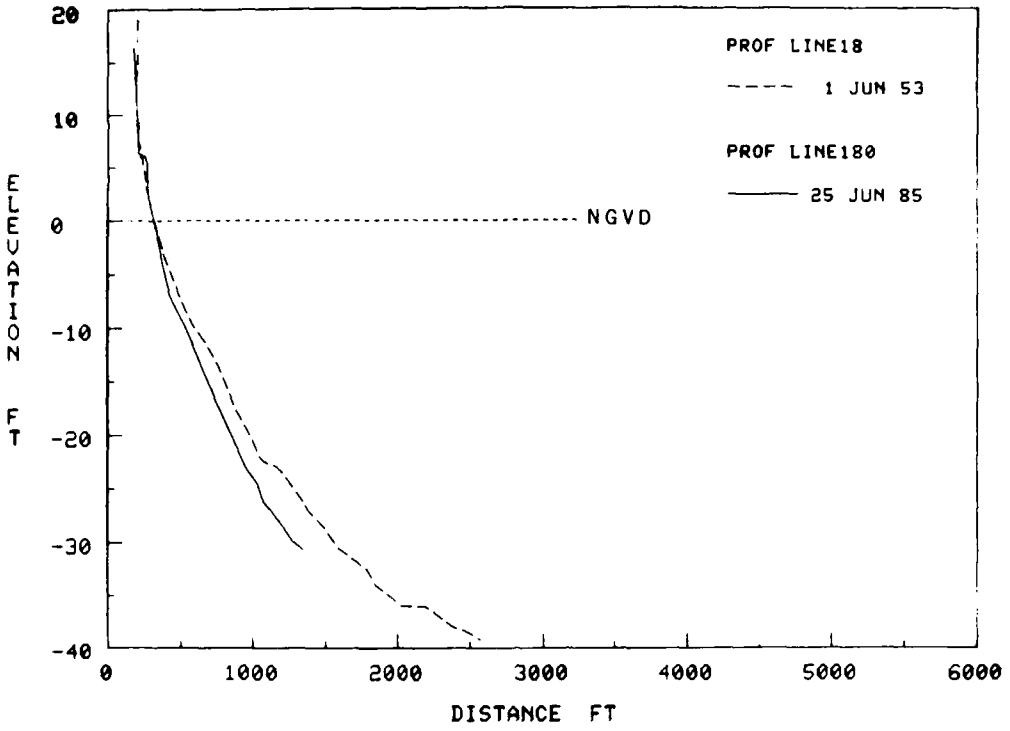


Figure D16. Profile comparisons 1953-1985, lines 16 and 17 (160 and 170)



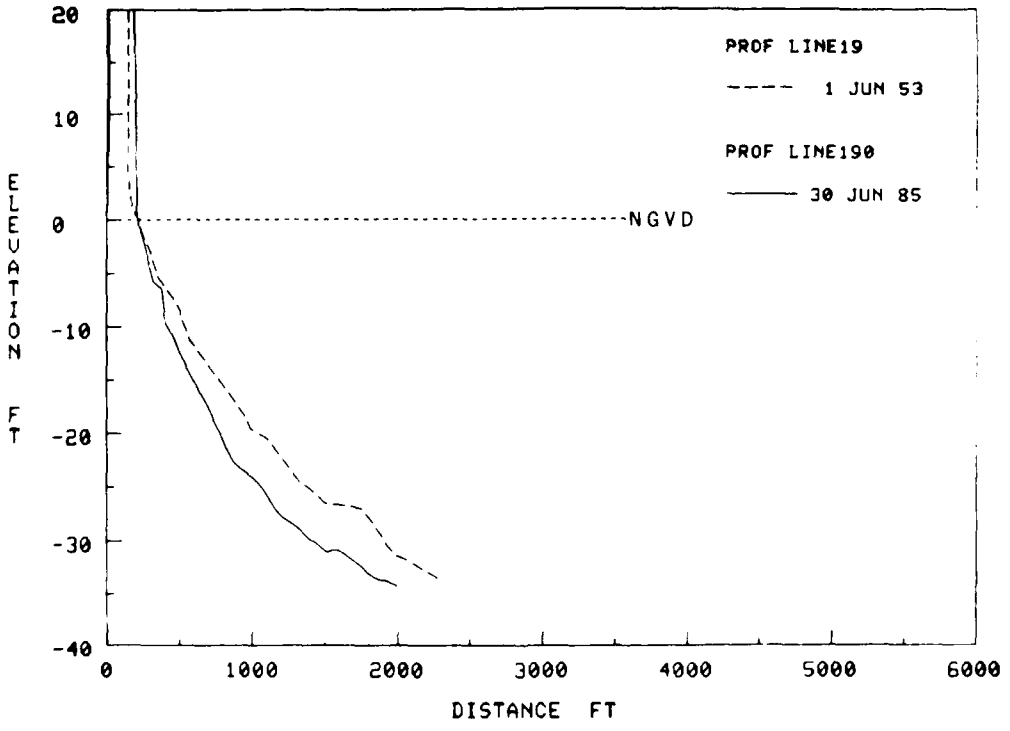
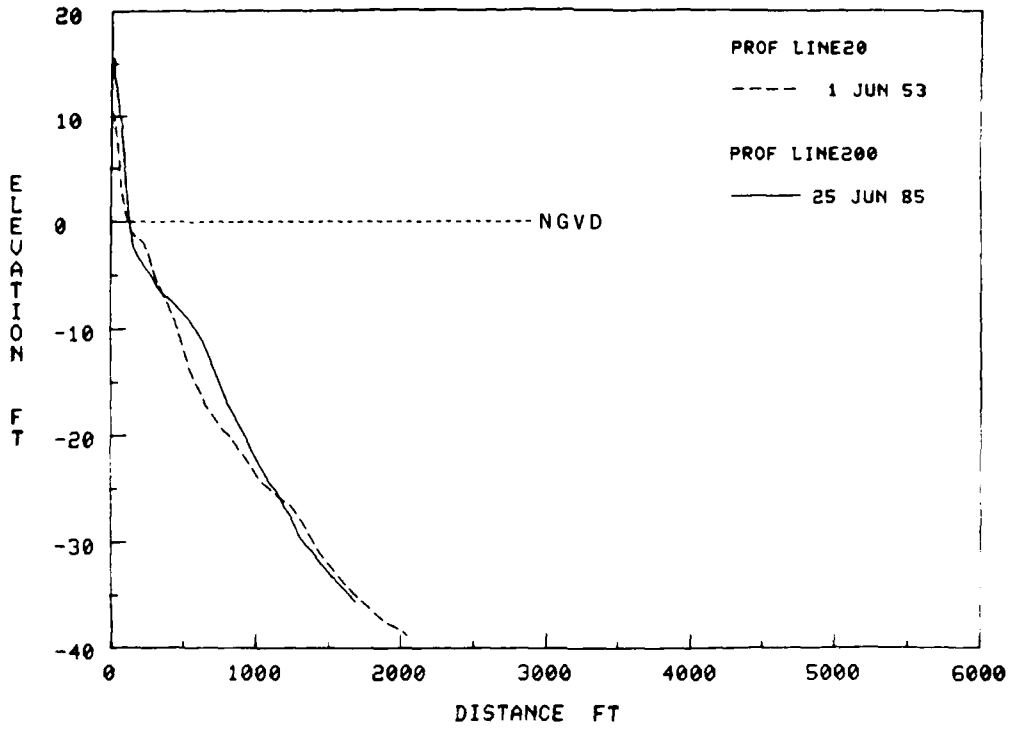


Figure D17. Profile comparisons 1953-1985, lines 18 and 19 (180 and 190)



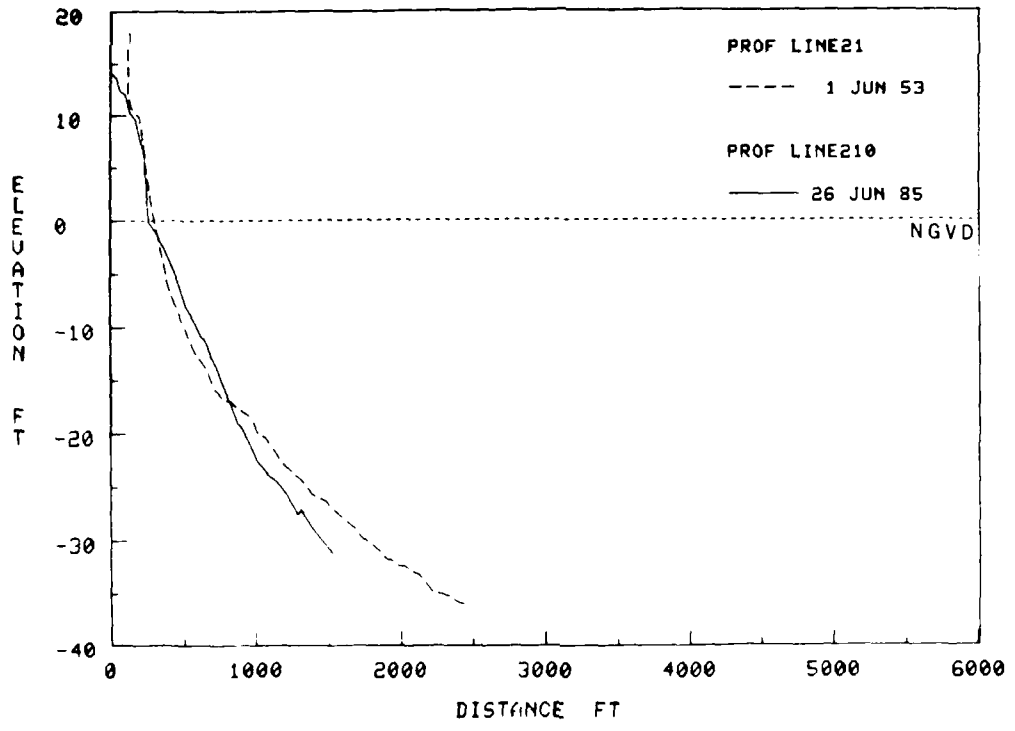
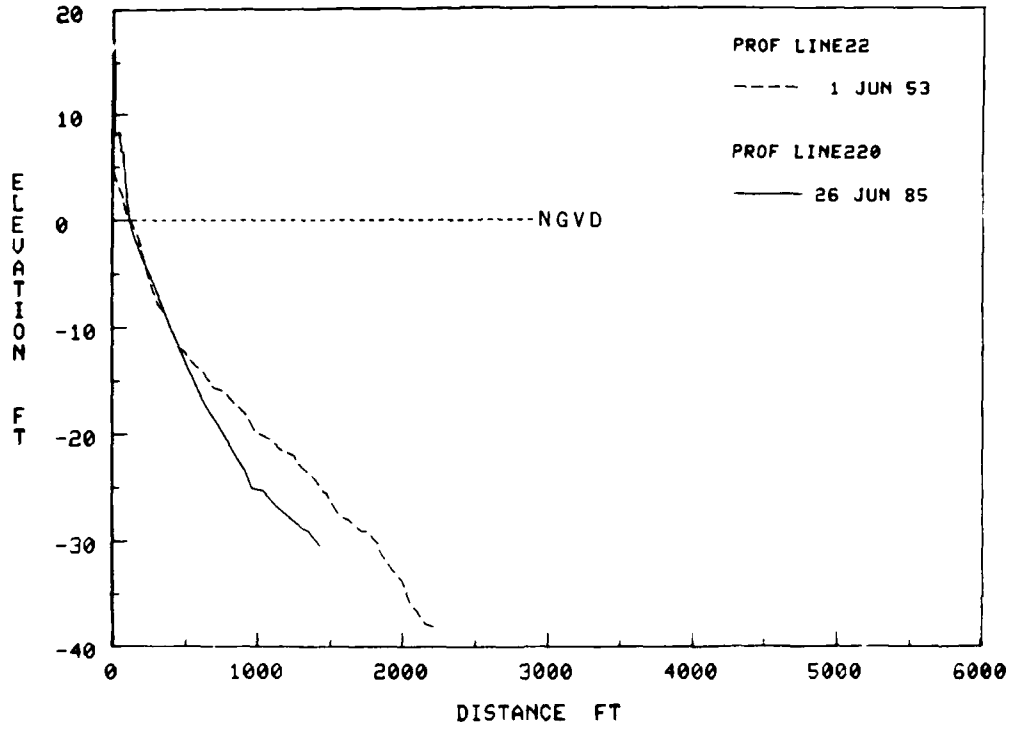


Figure D18. Profile comparisons 1953-1985, lines 20 and 21 (200 and 210)



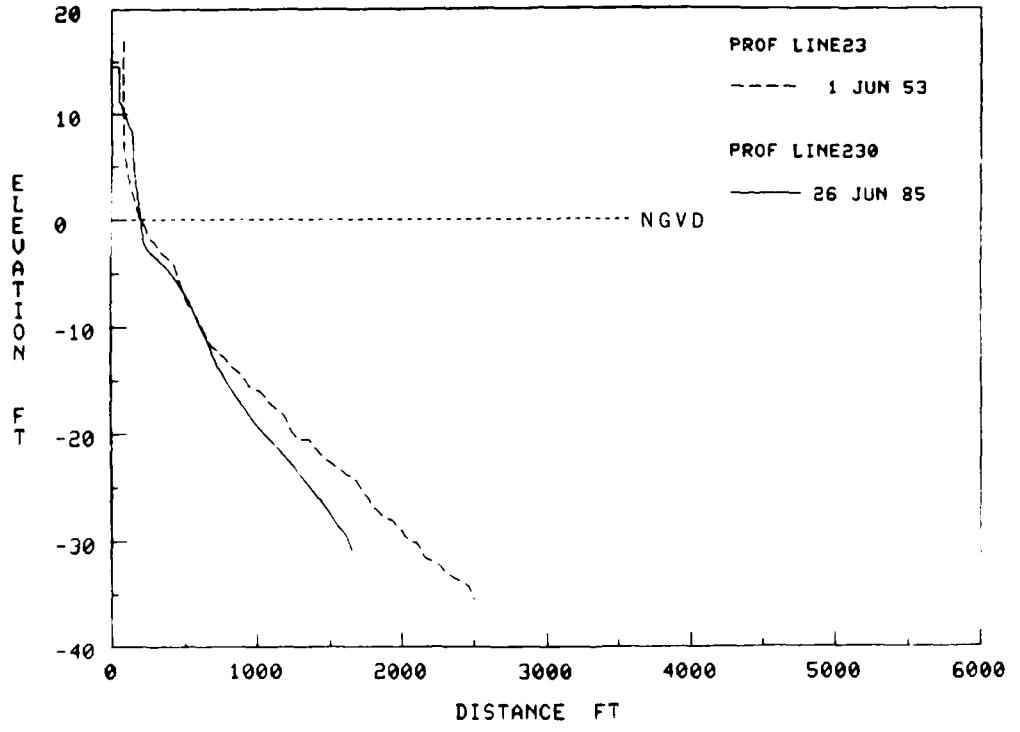


Figure 19. Profile comparisons 1953-1985, lines 22 and 23 (220 and 230)

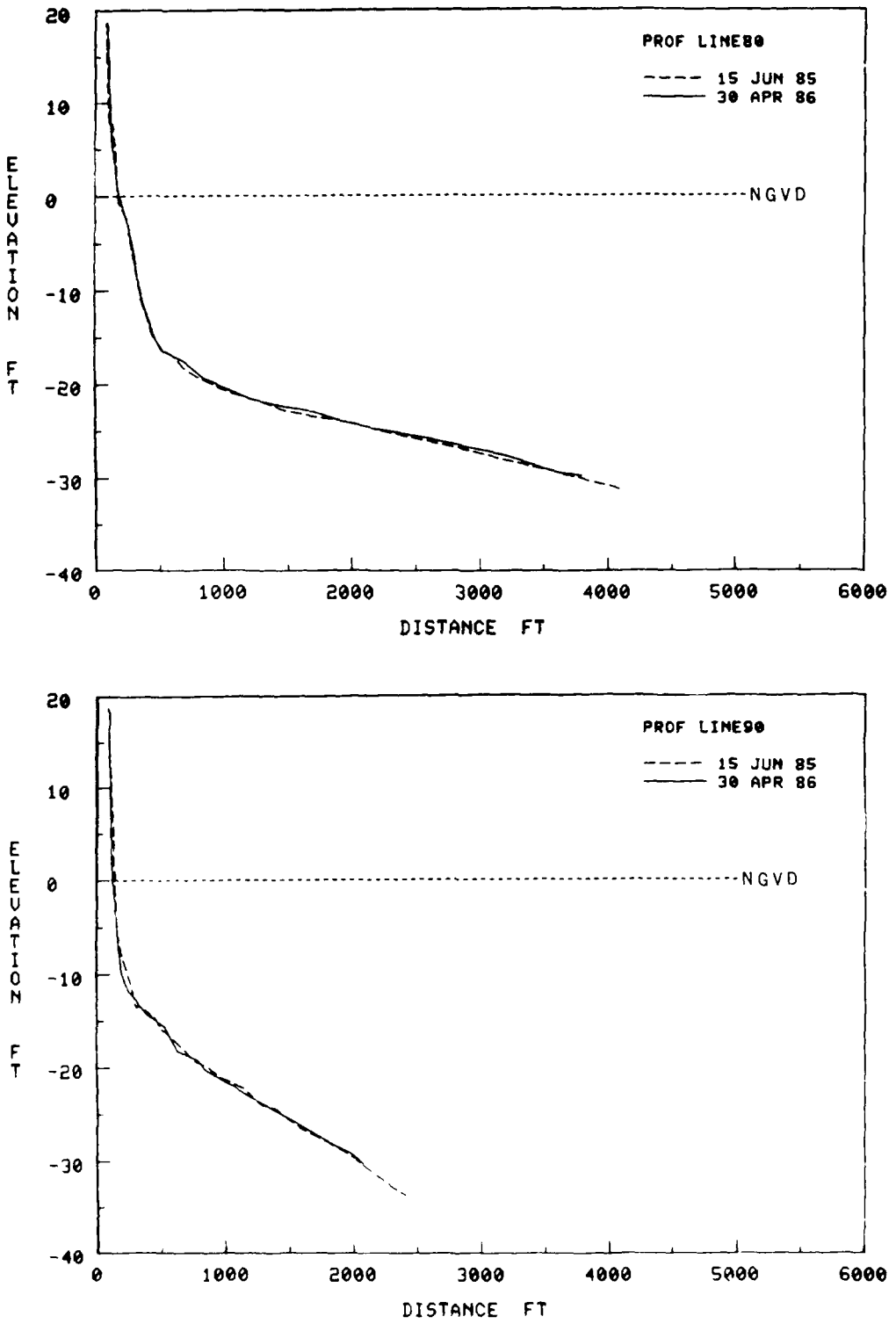
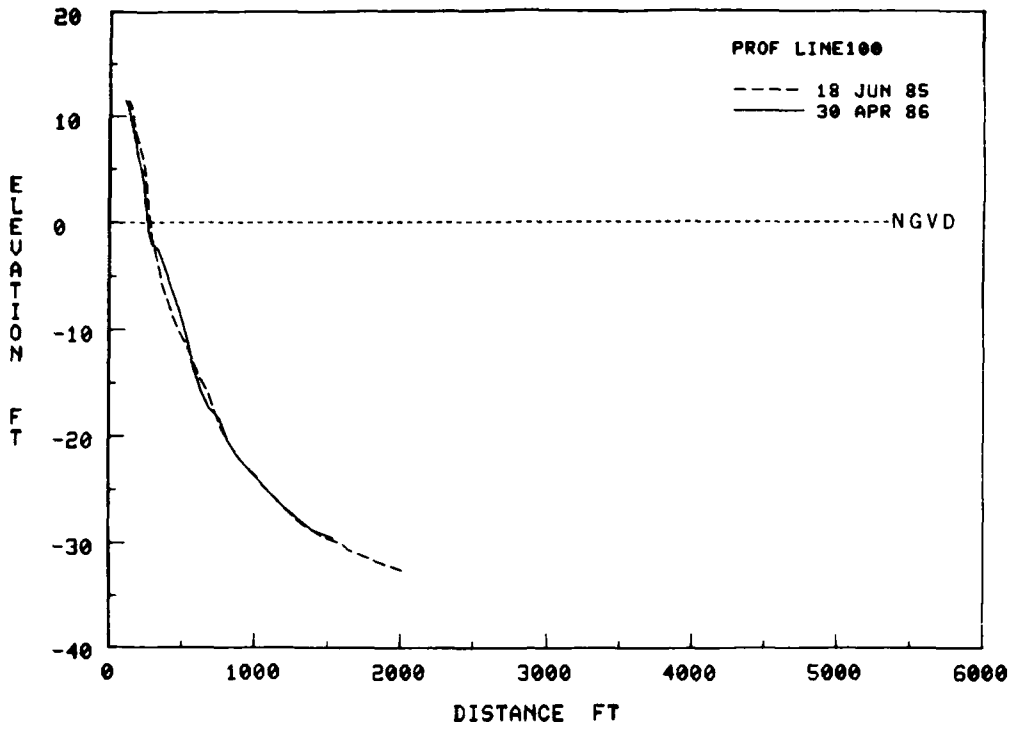


Figure D20. Profile comparisons 1985-1986, lines 80 and 90



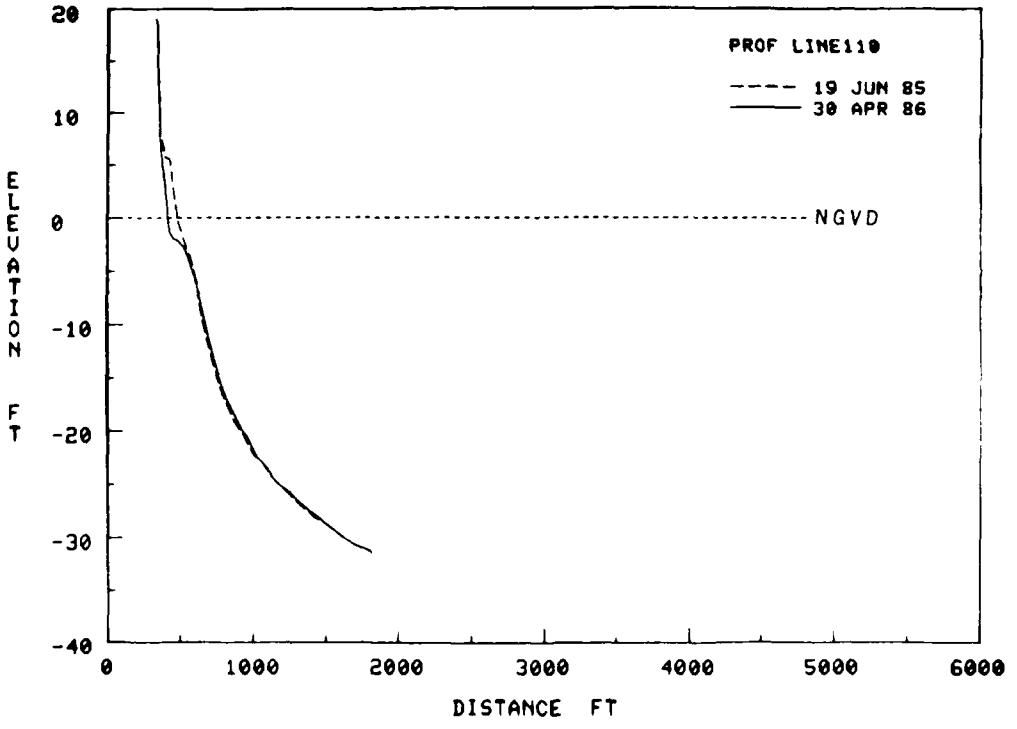
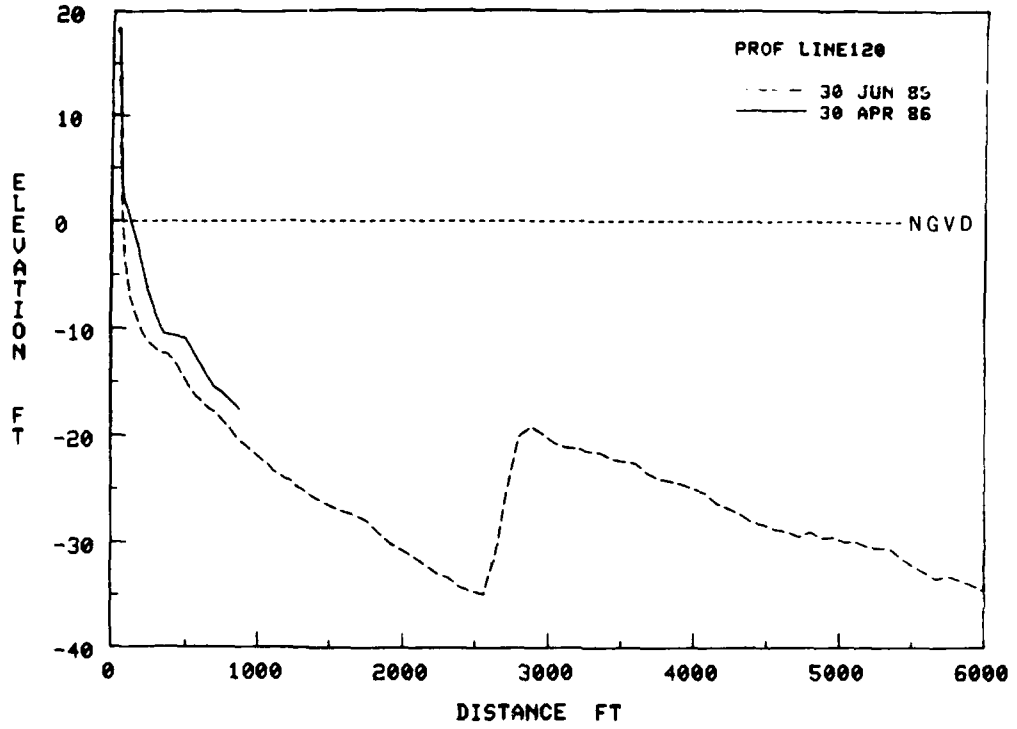


Figure D21. Profile comparisons 1985-1986, lines 100 and 110



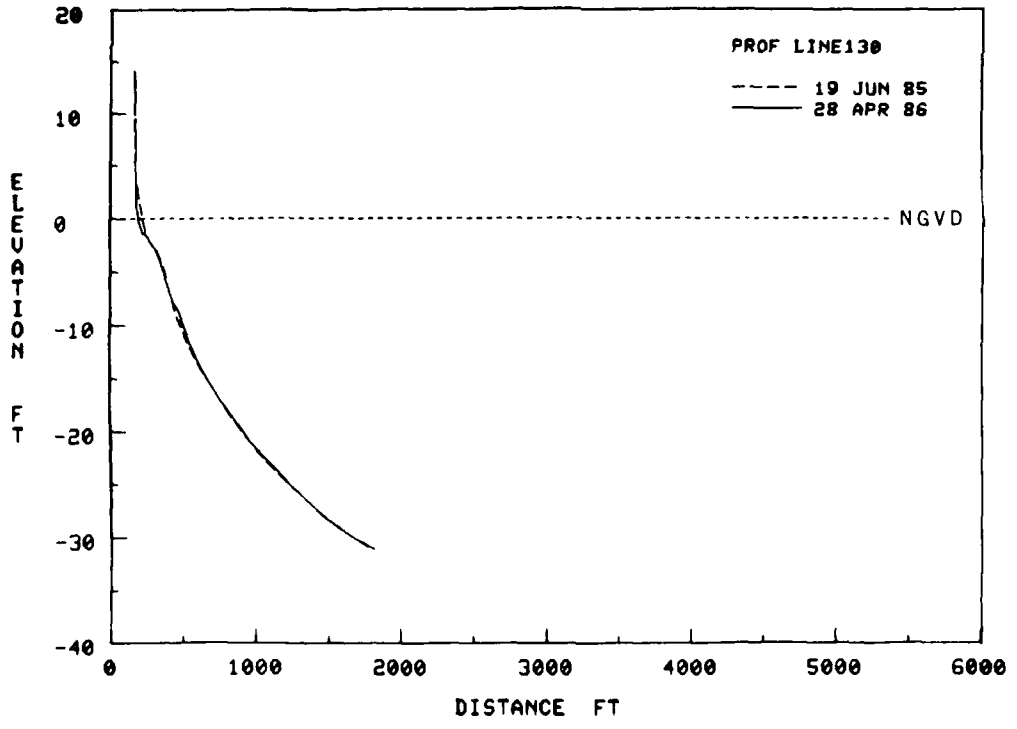
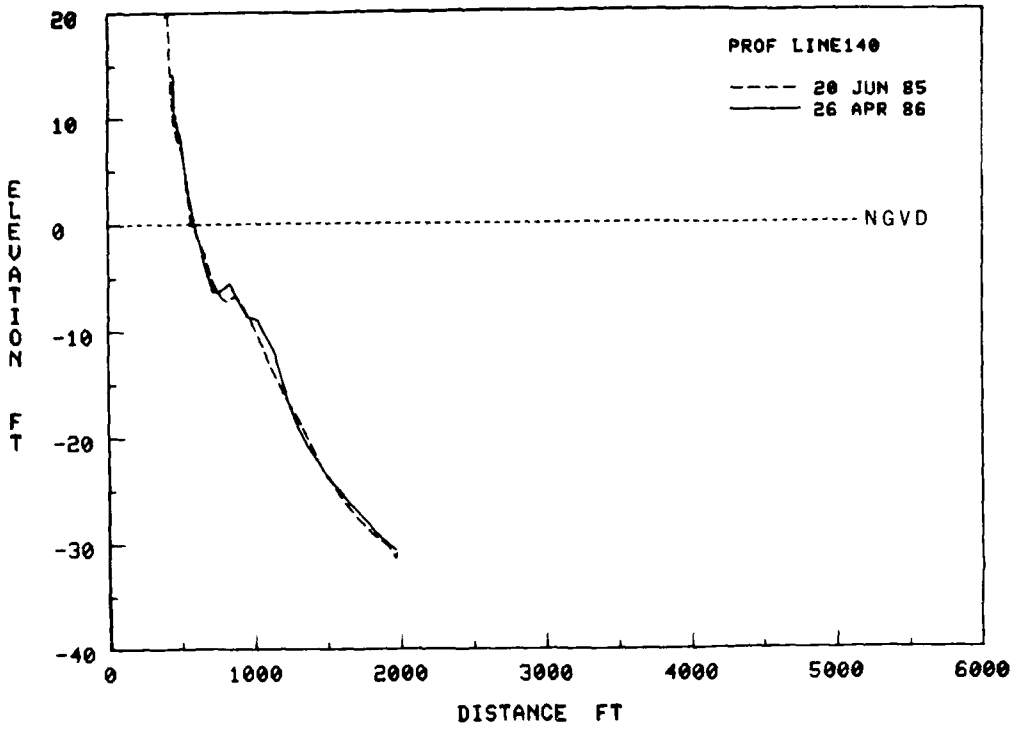


Figure D22. Profile comparisons 1985-1986, lines 120 and 130



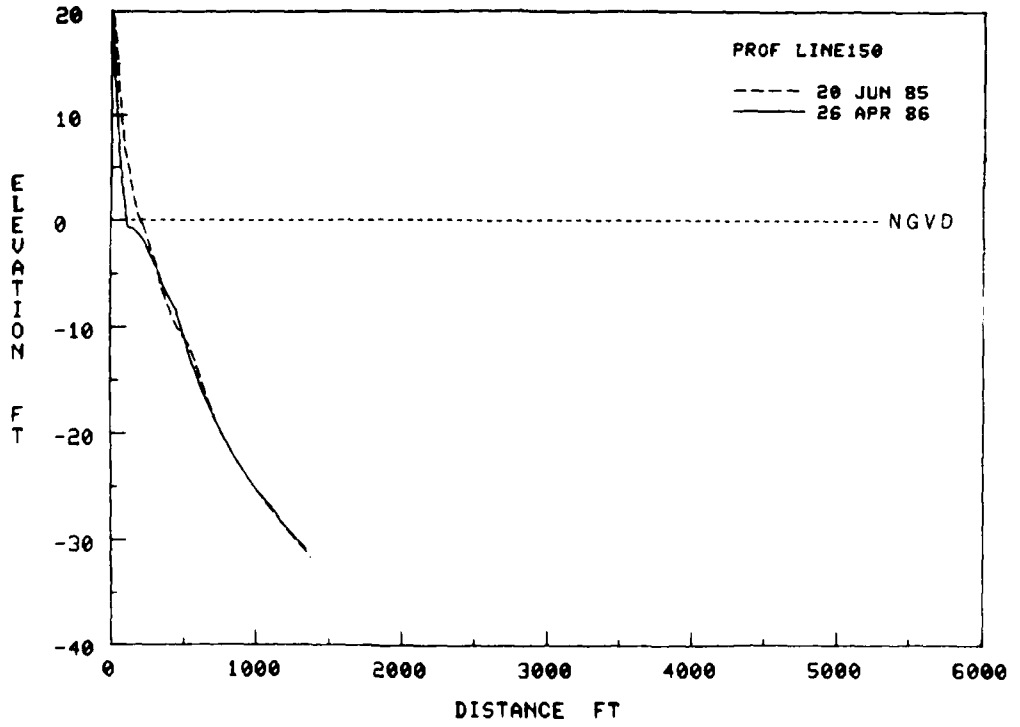
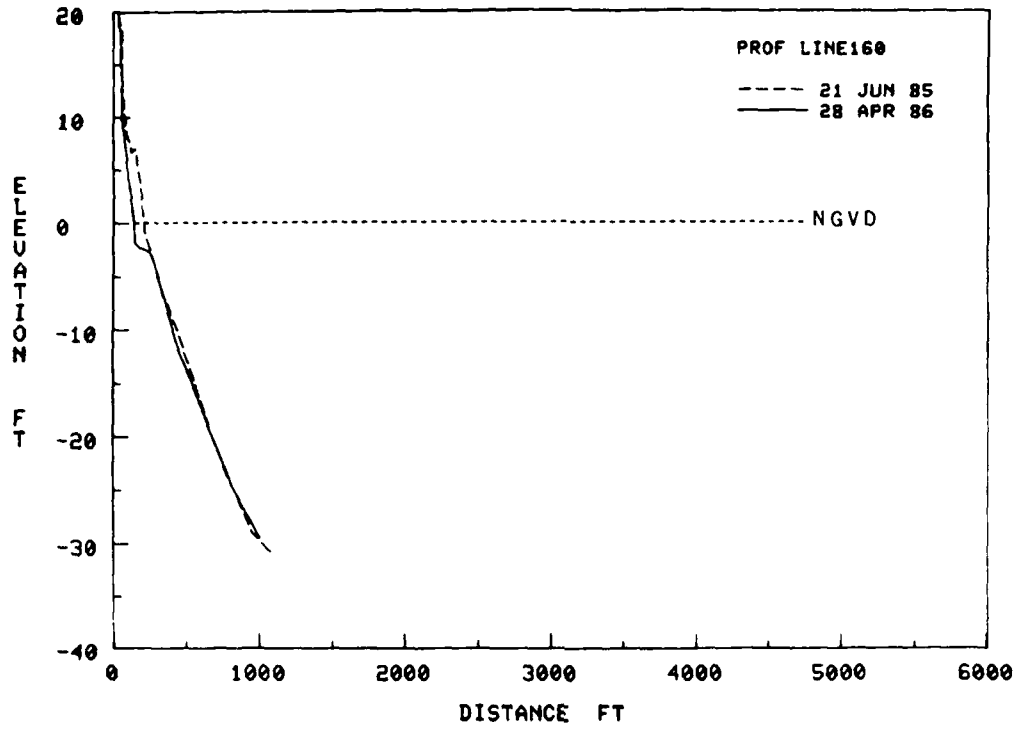


Figure D23. Profile comparisons 1985-1986, lines 140 and 150



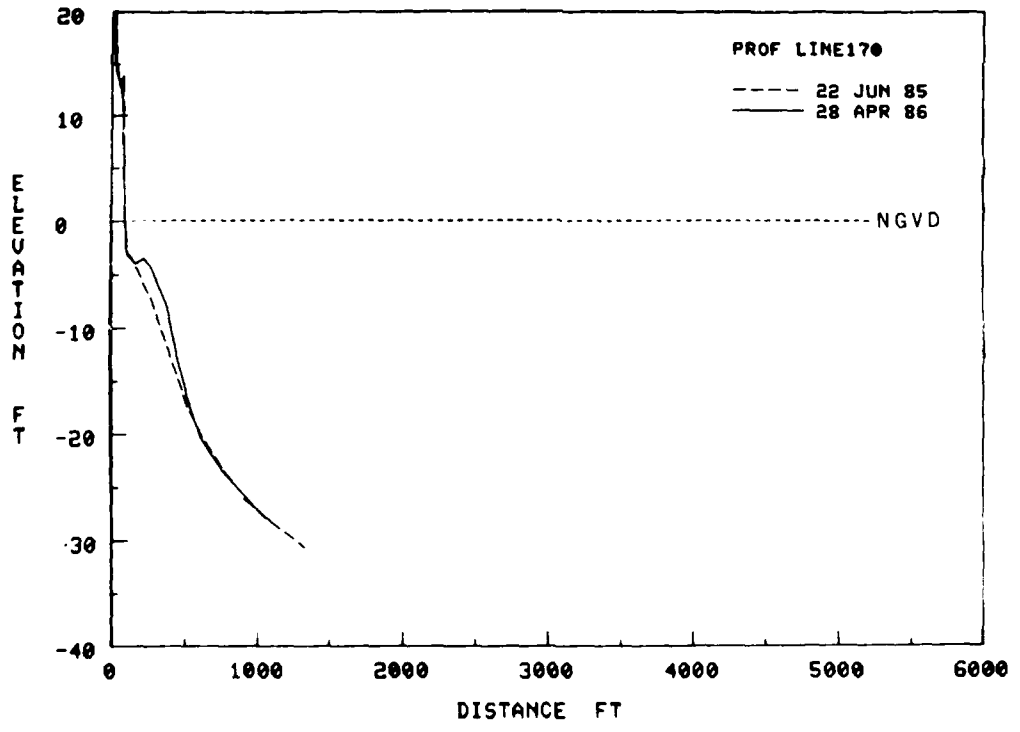
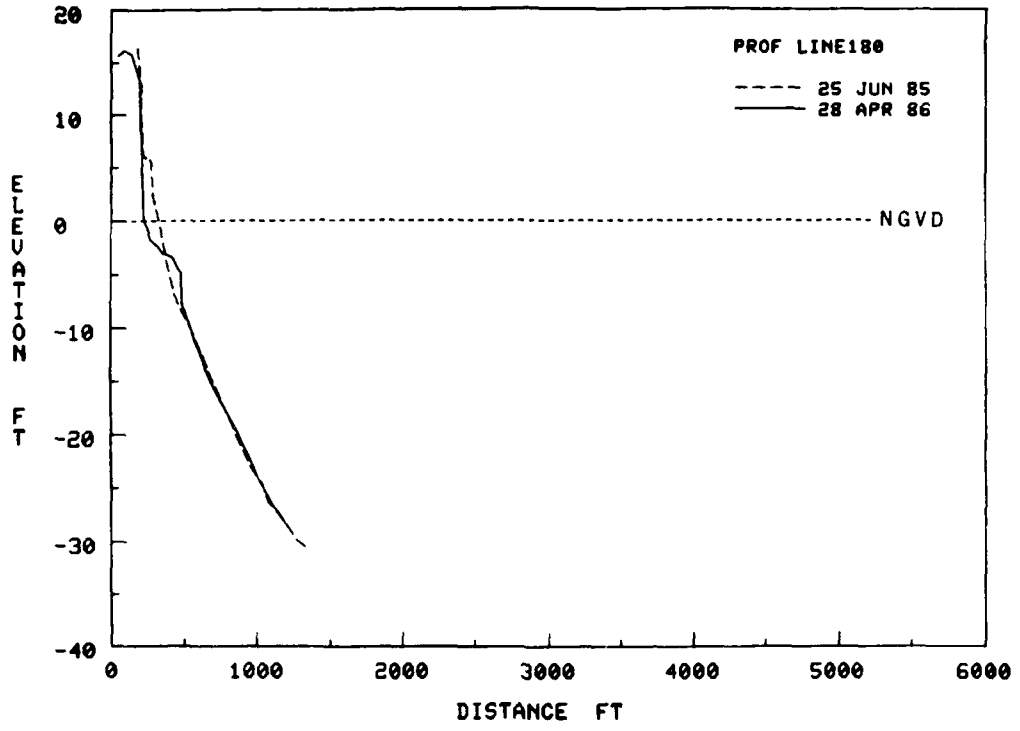


Figure D24. Profile comparisons 1985-1986, lines 160 and 170



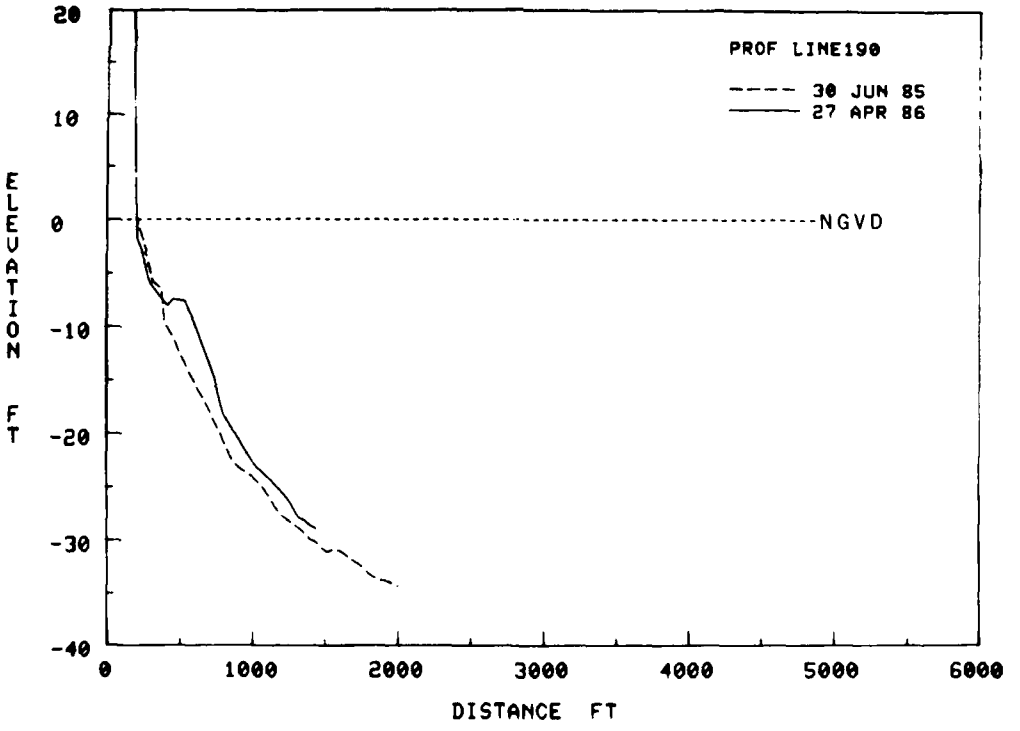


Figure D25. Profile comparisons 1985-1986, lines 180 and 190

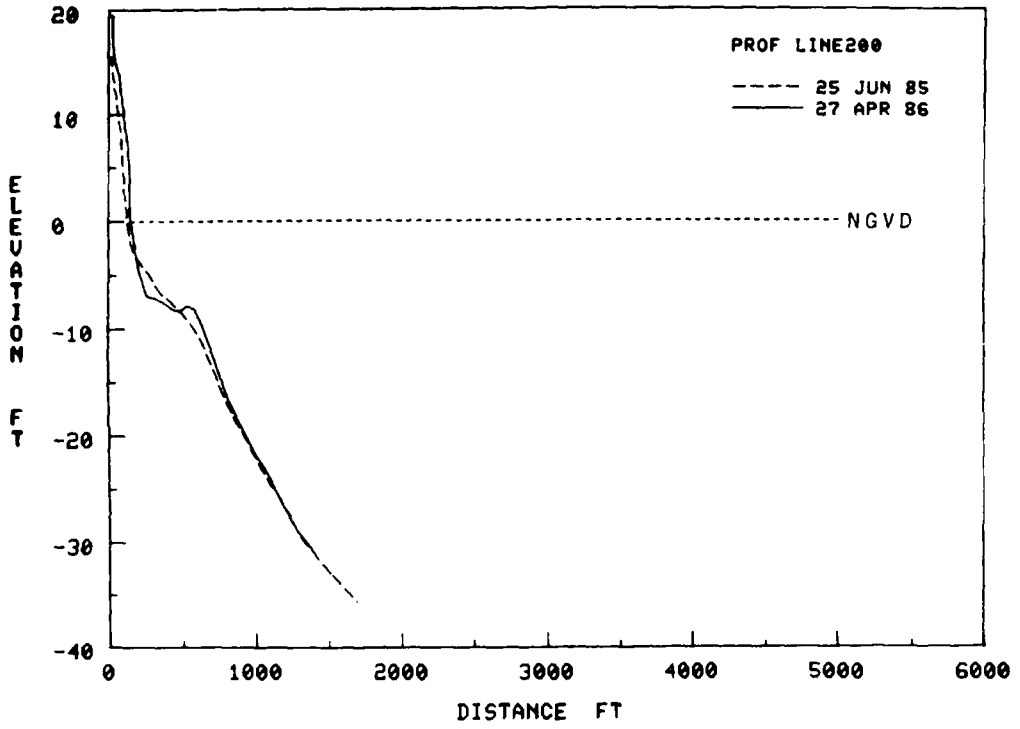
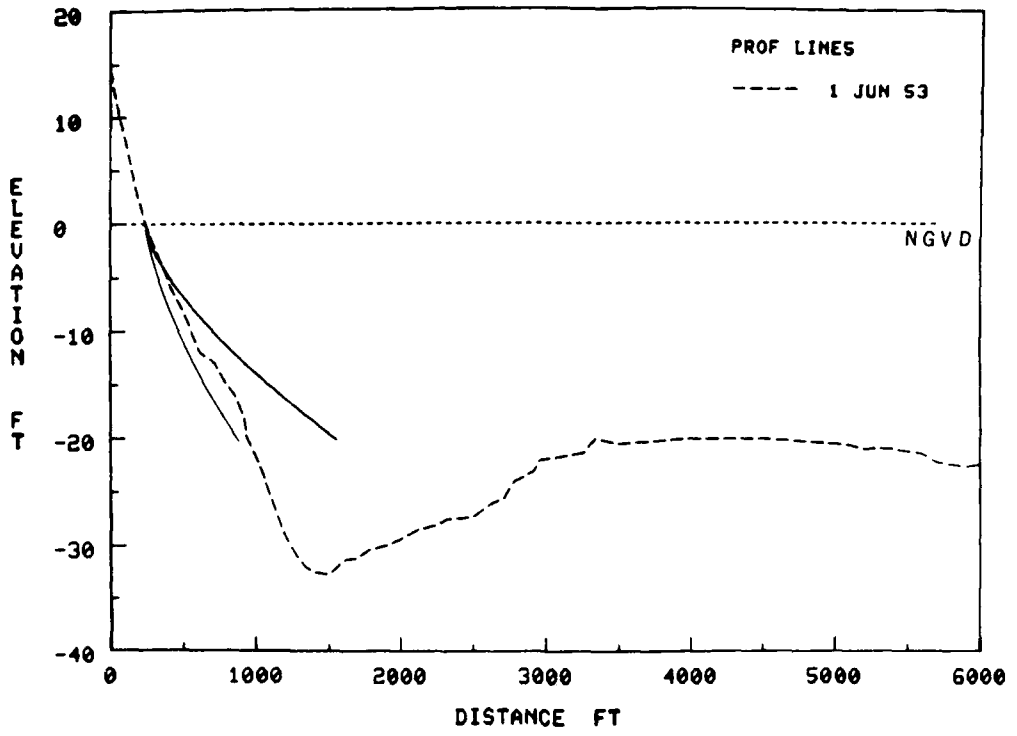


Figure D26. Profile comparisons 1985-1986, line 200



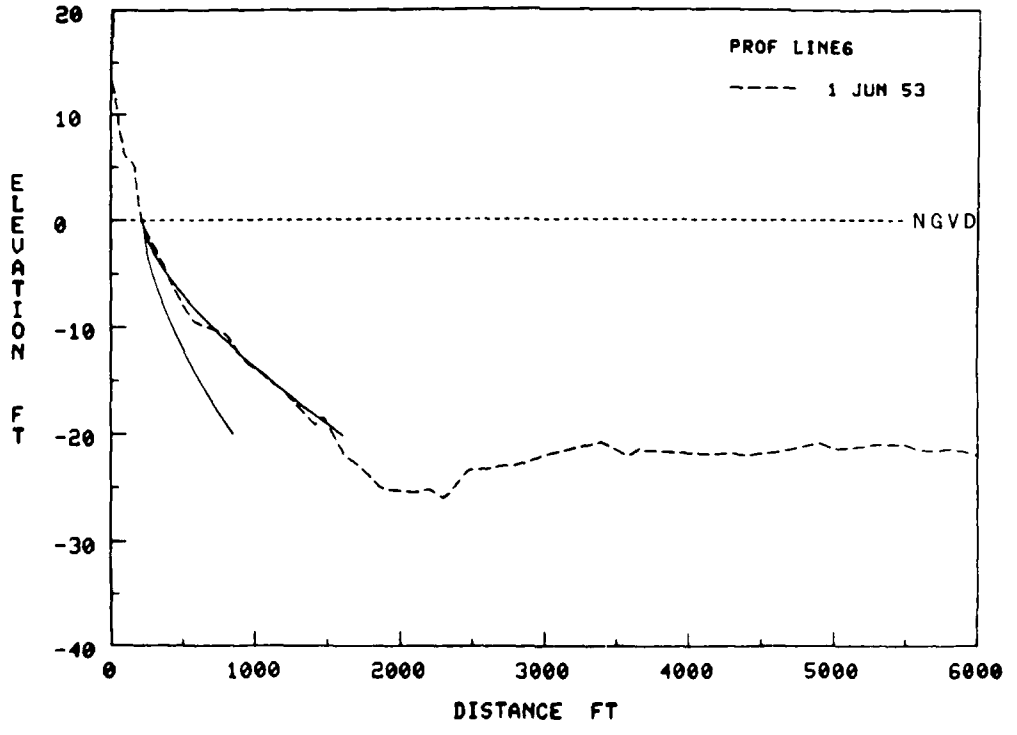
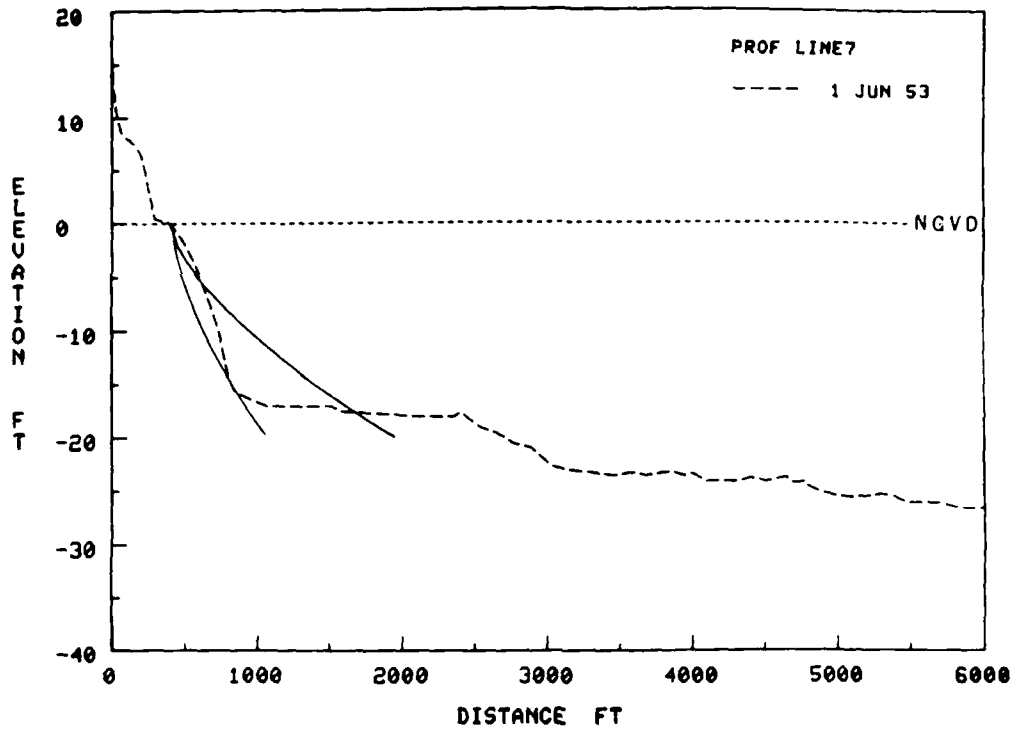


Figure D27. Profile lines 5 and 6, 1953, with equilibrium envelope



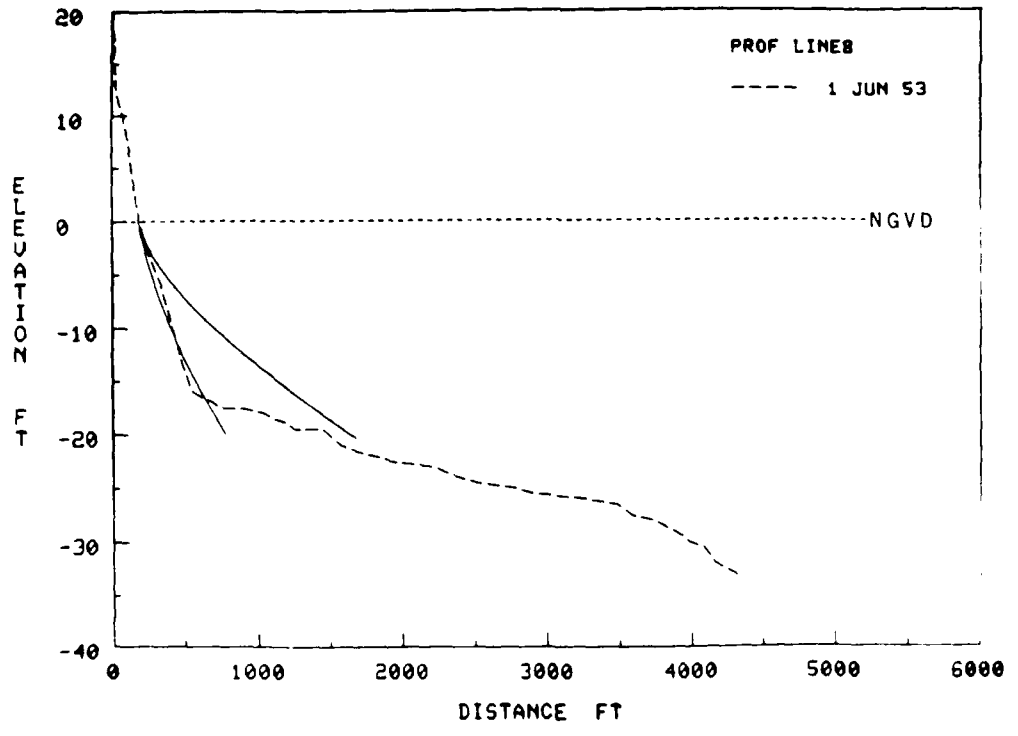
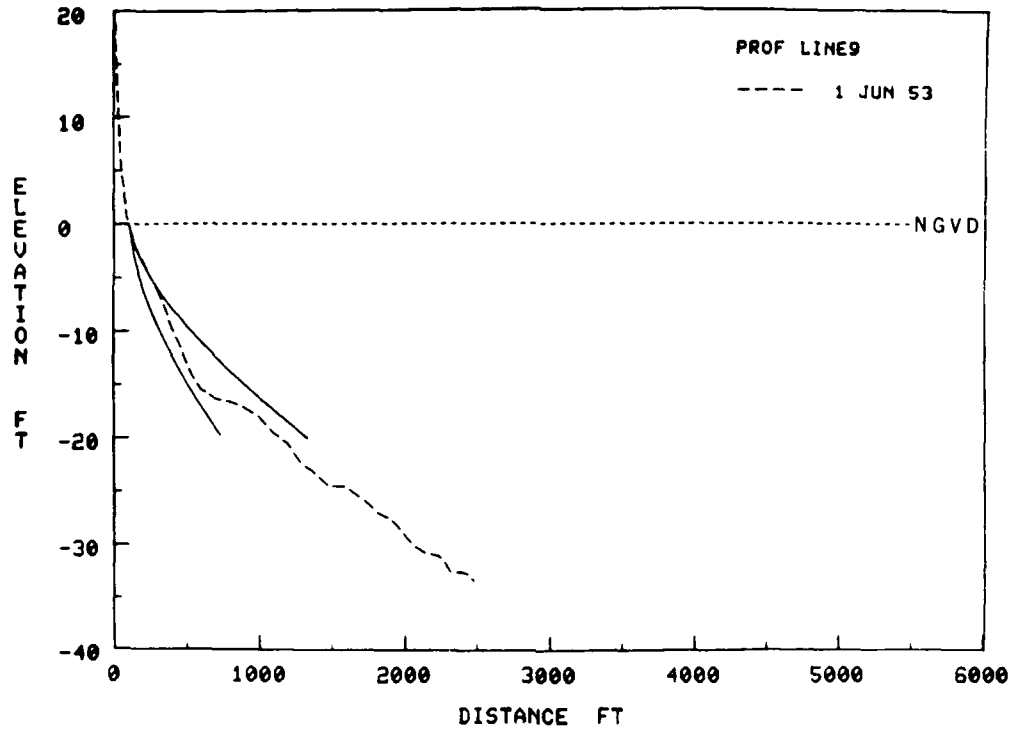


Figure D28. Profile lines 7 and 8, 1953, with equilibrium envelope



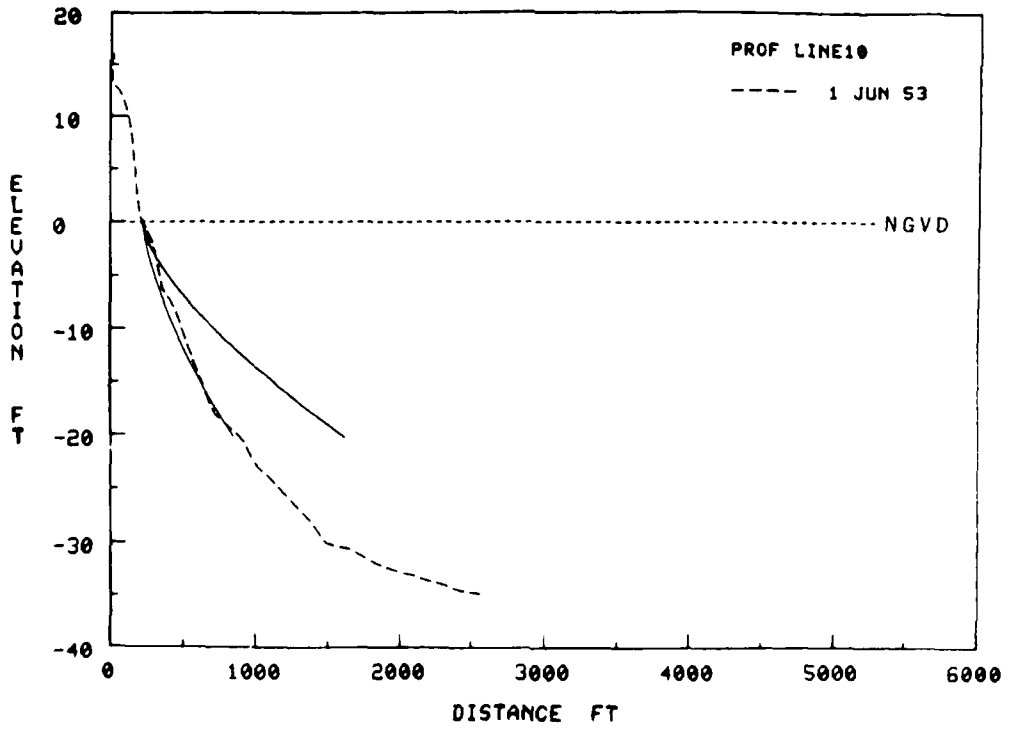
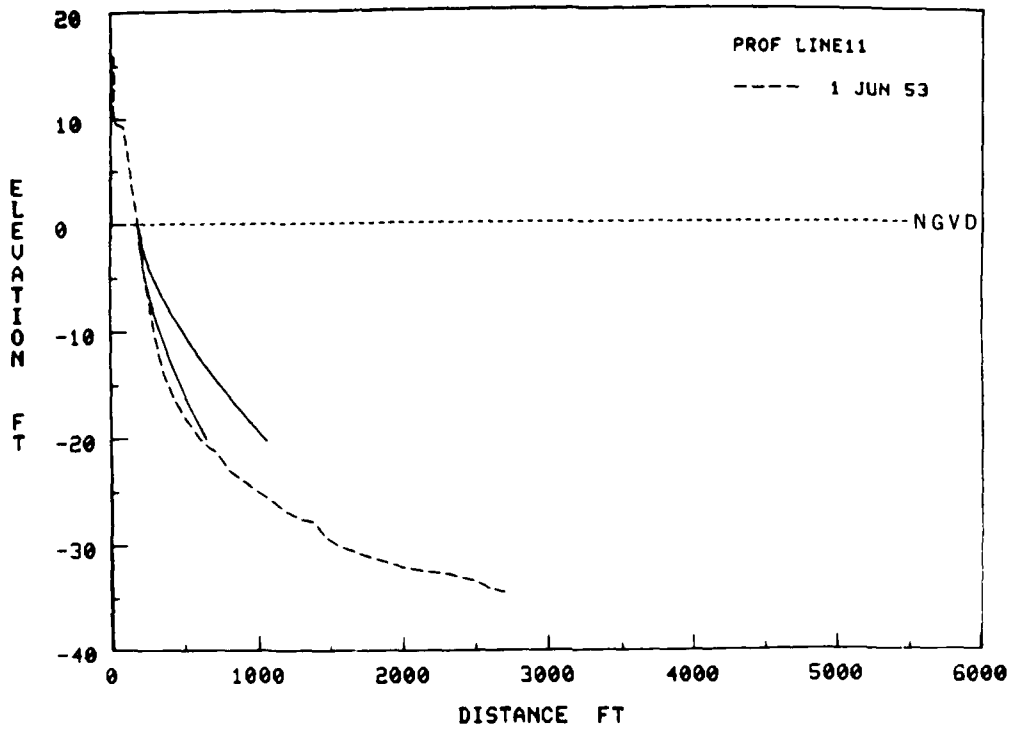


Figure D29. Profile lines 9 and 10, 1953, with equilibrium envelope



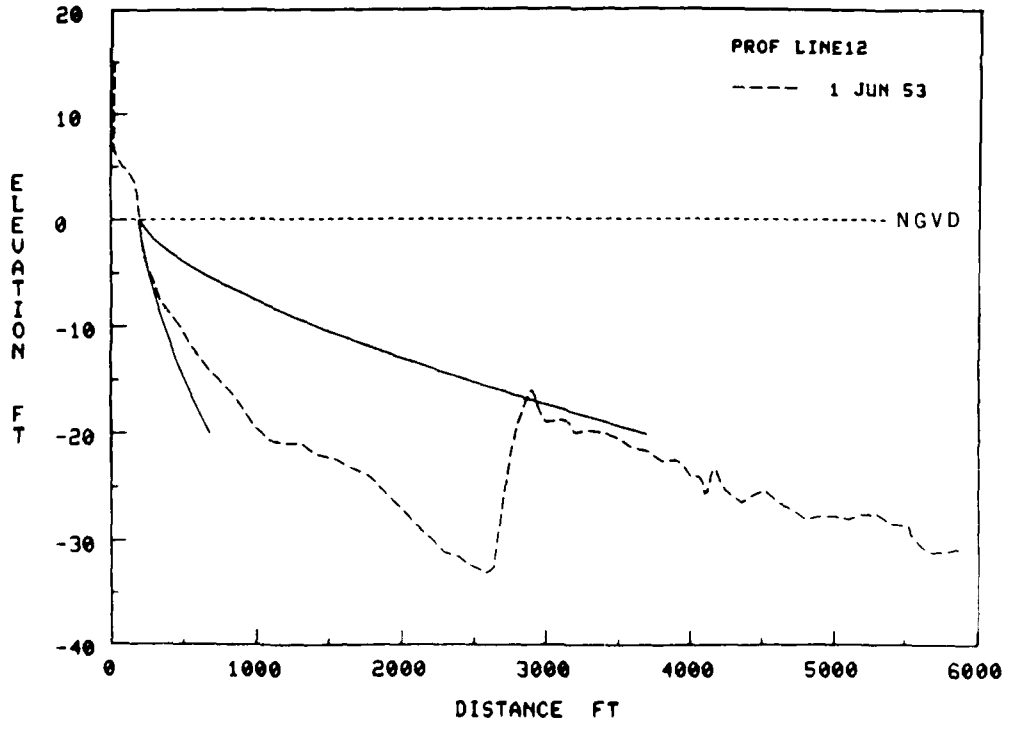
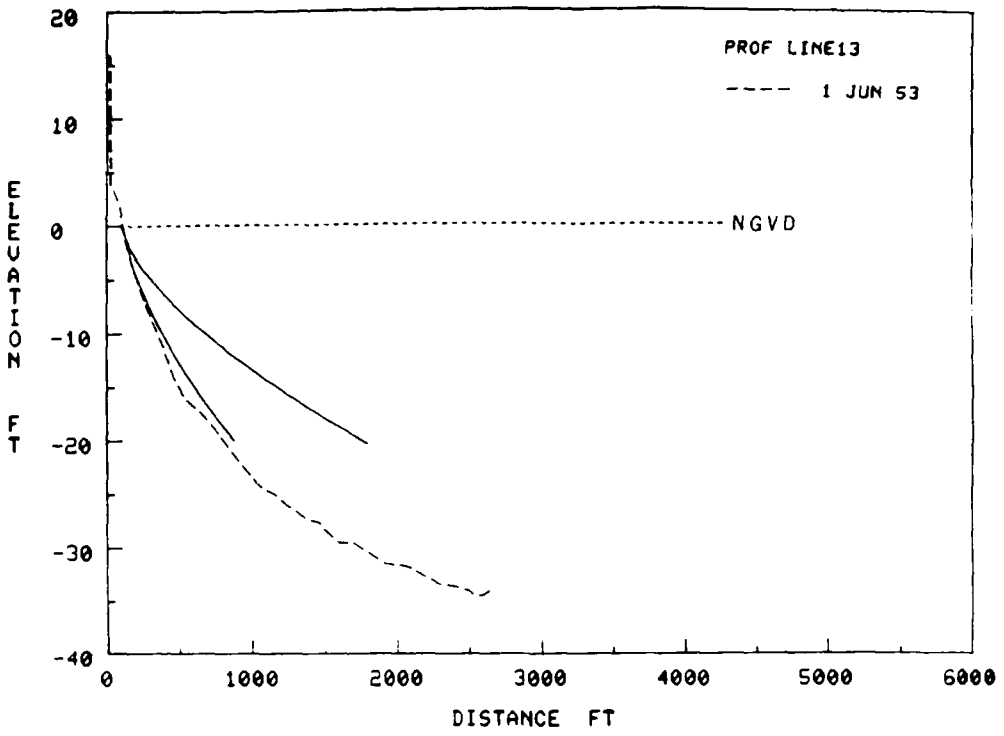


Figure D30. Profile lines 11 and 12, 1953, with equilibrium envelope



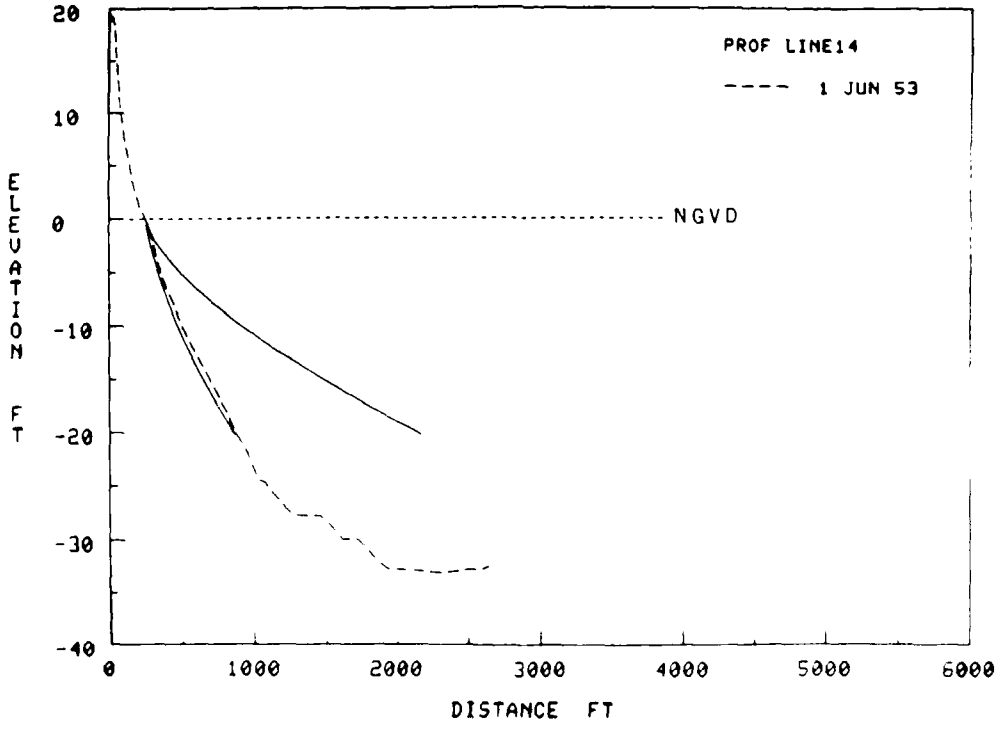
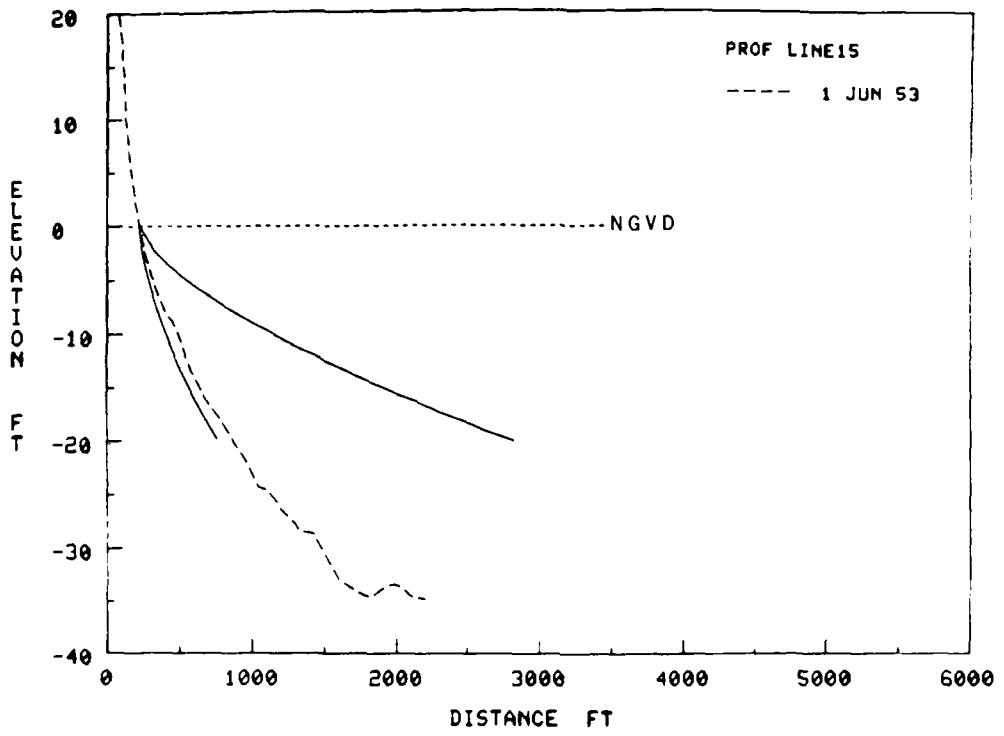


Figure D31. Profile lines 13 and 14, 1953, with equilibrium envelope



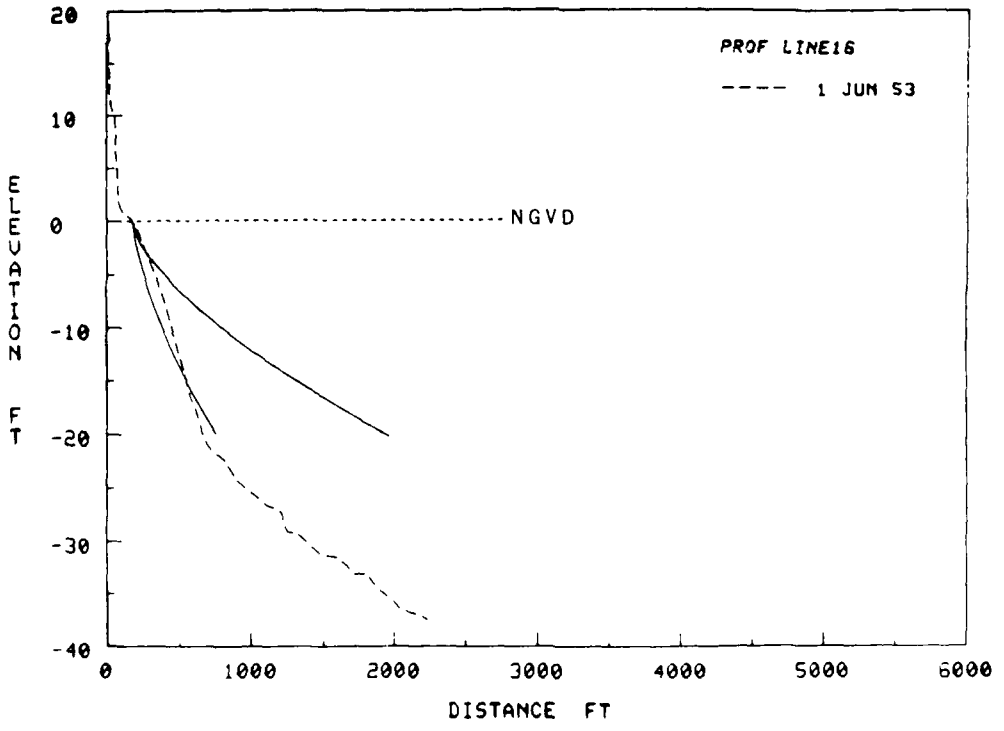
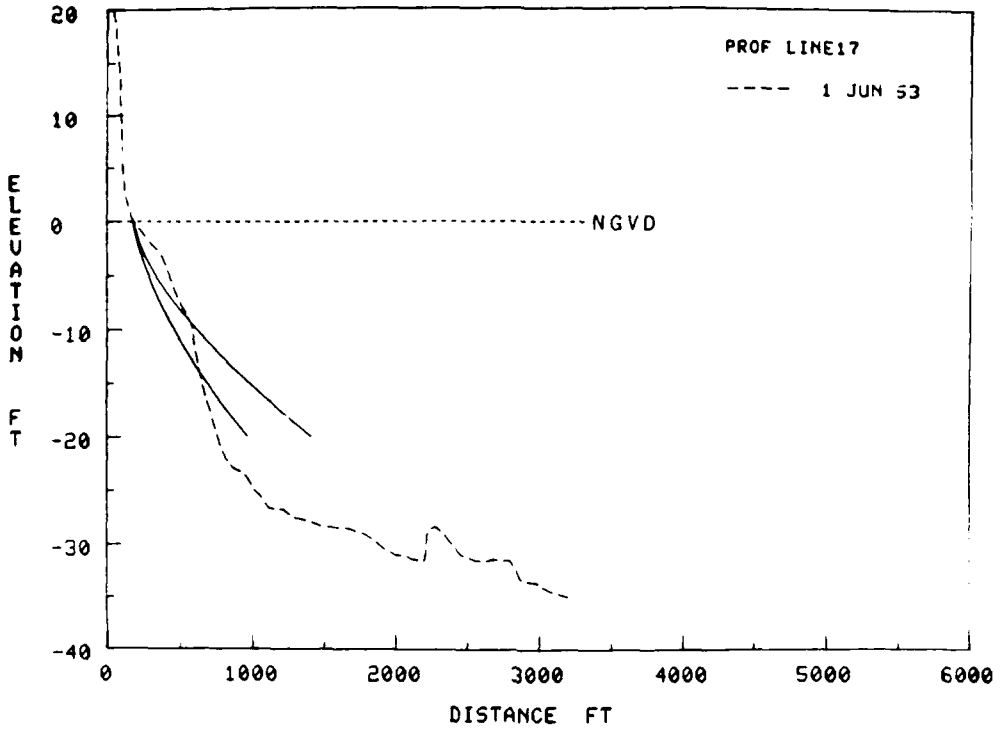


Figure D32. Profile lines 15 and 16, 1953, with equilibrium envelope



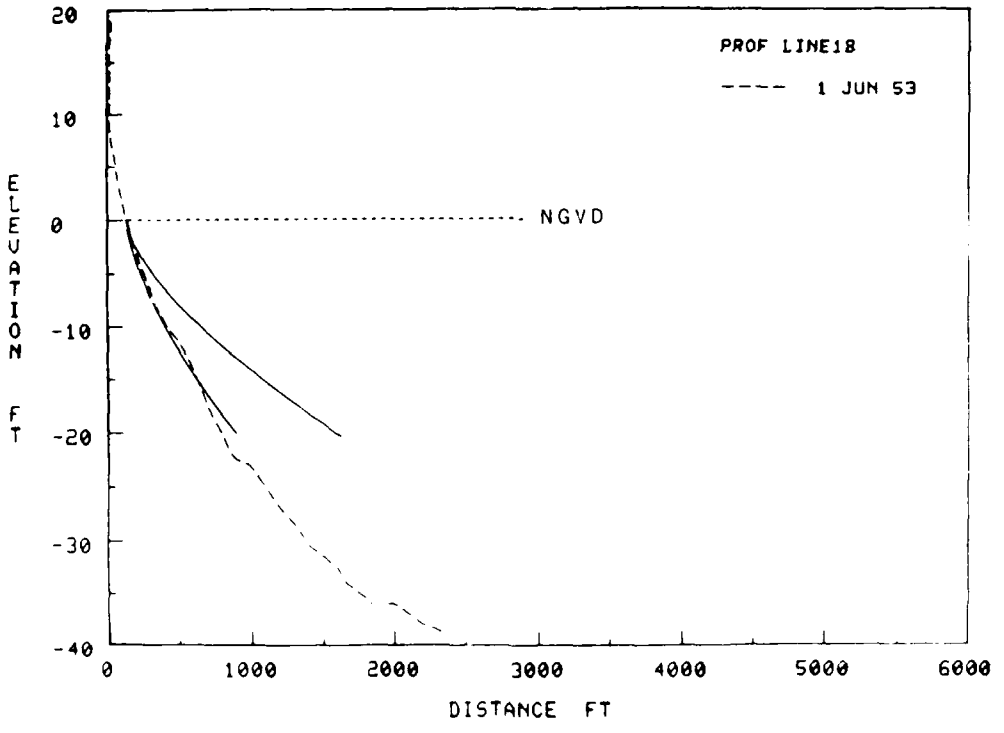
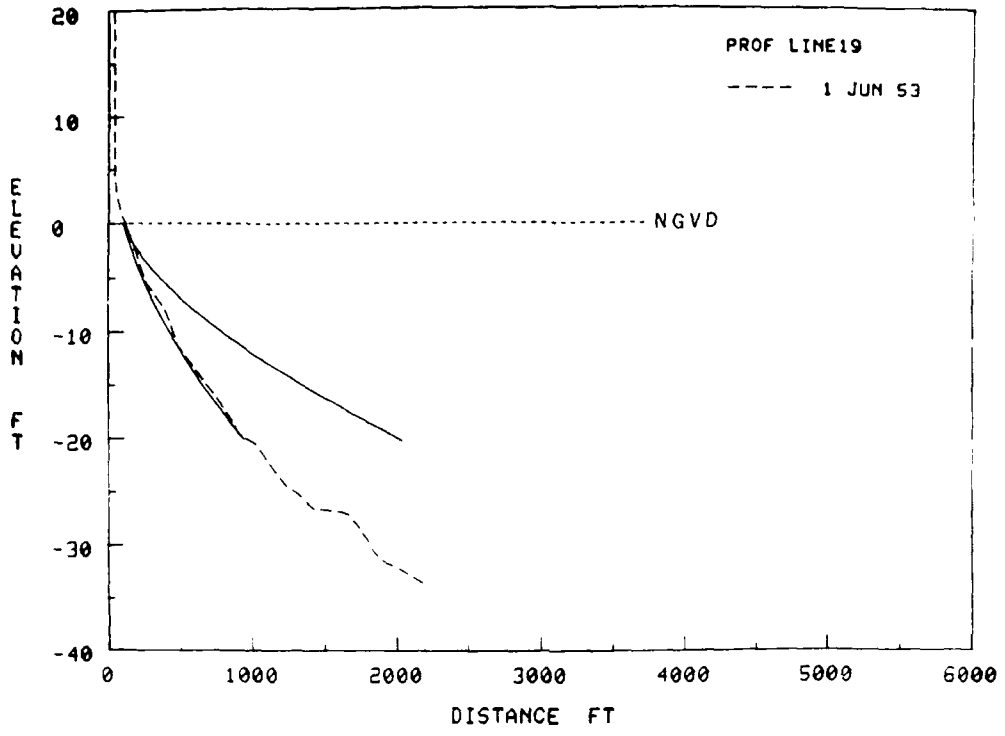


Figure D33. Profile lines 17 and 18, 1953, with equilibrium envelope



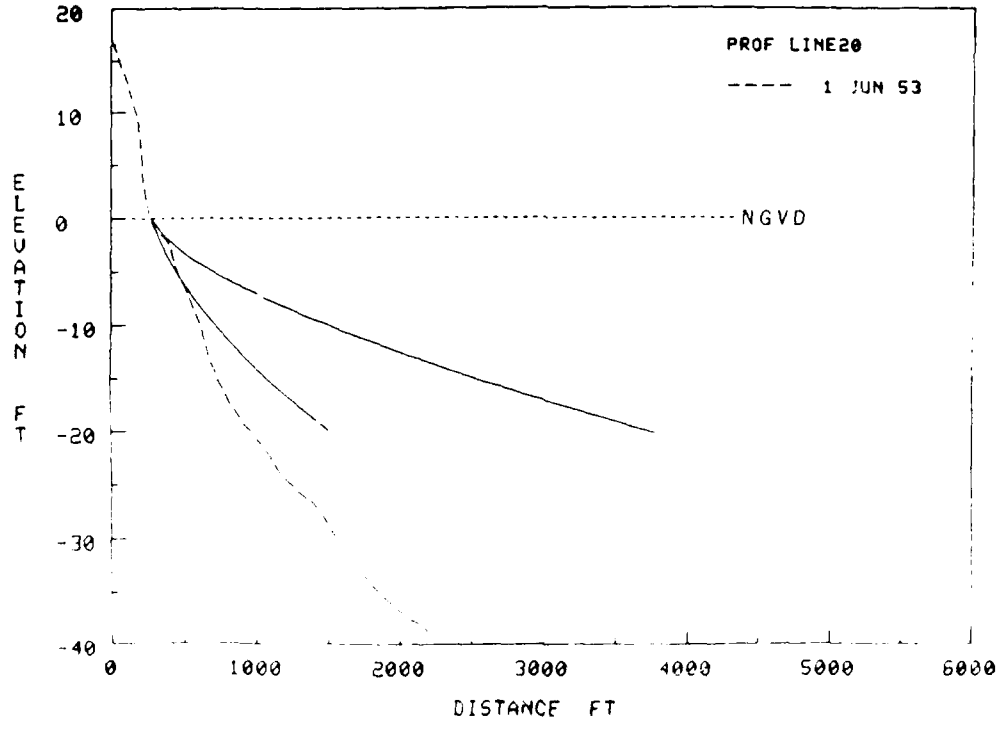
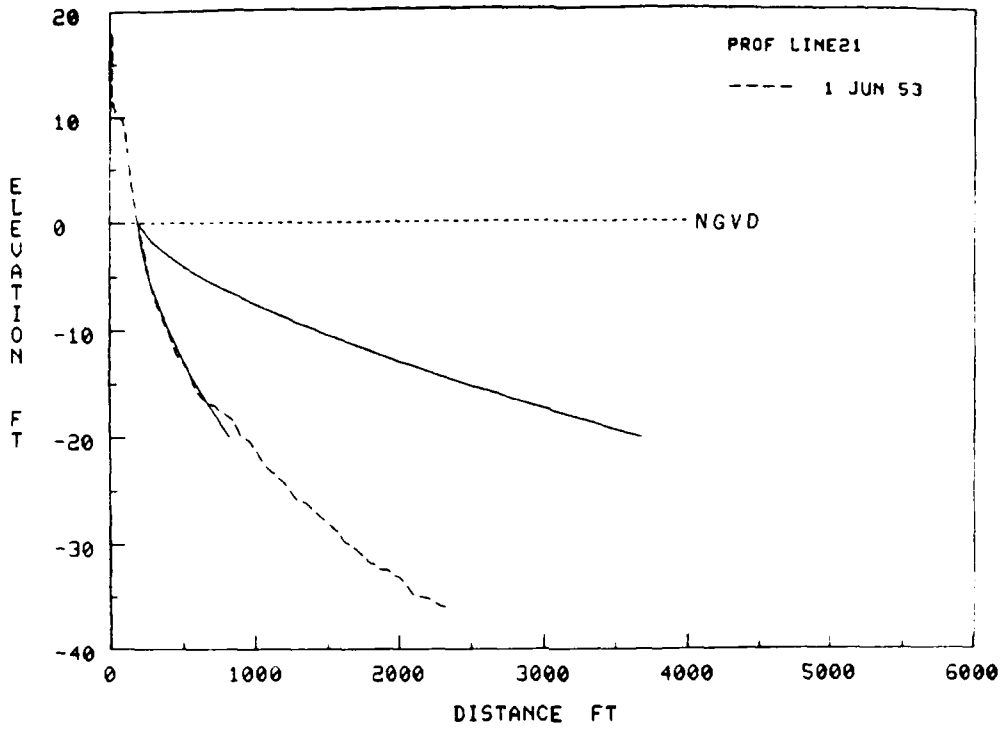


Figure D34. Profile lines 19 and 20, 1953, with equilibrium envelope



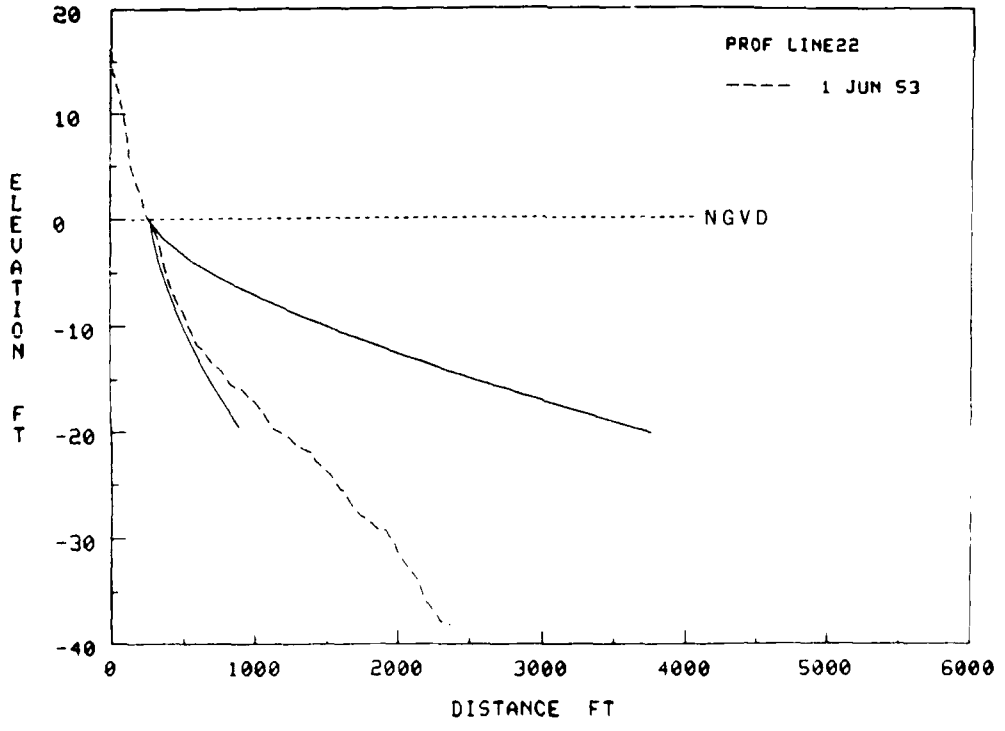


Figure D35. Profile lines 21 and 22, 1953, with equilibrium envelope

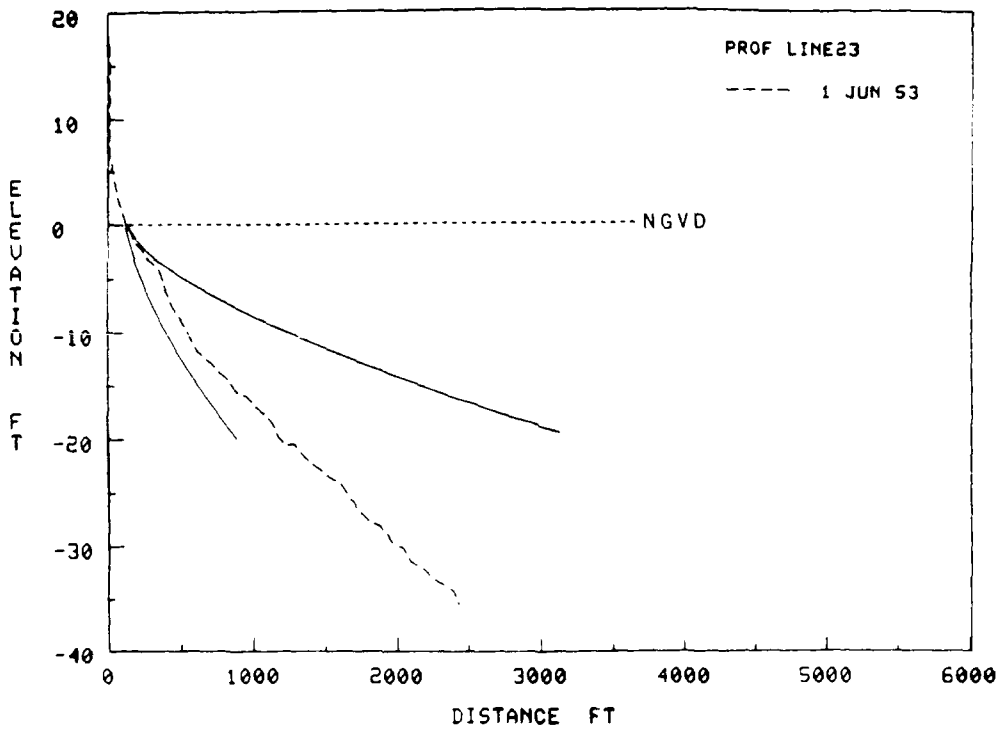
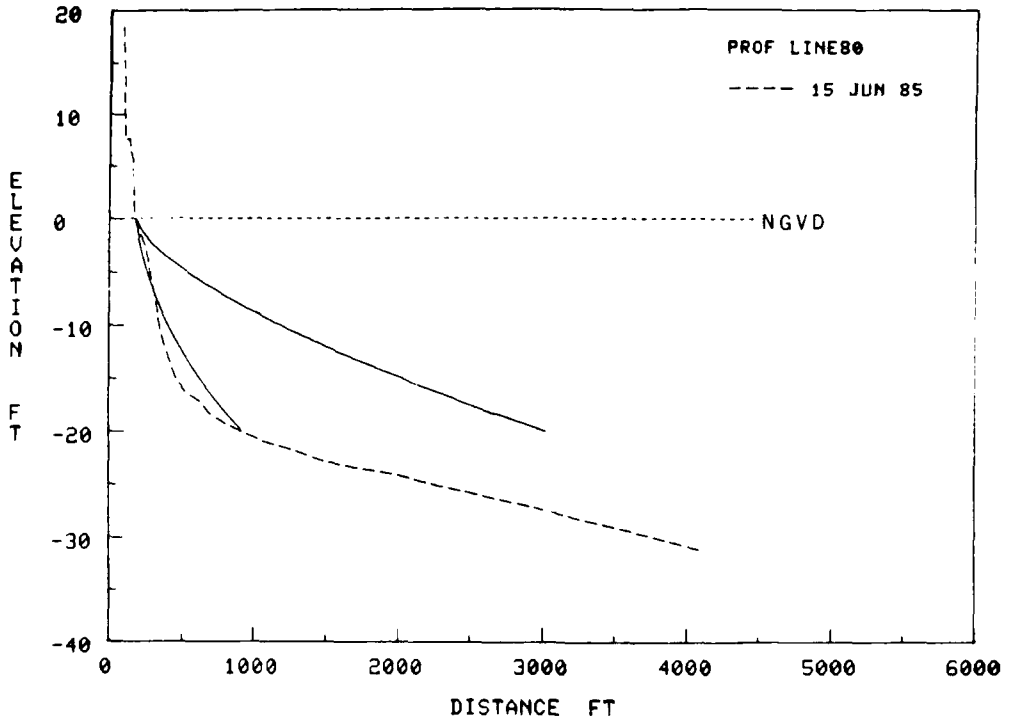


Figure D36. Profile line 23, 1953, with equilibrium envelope



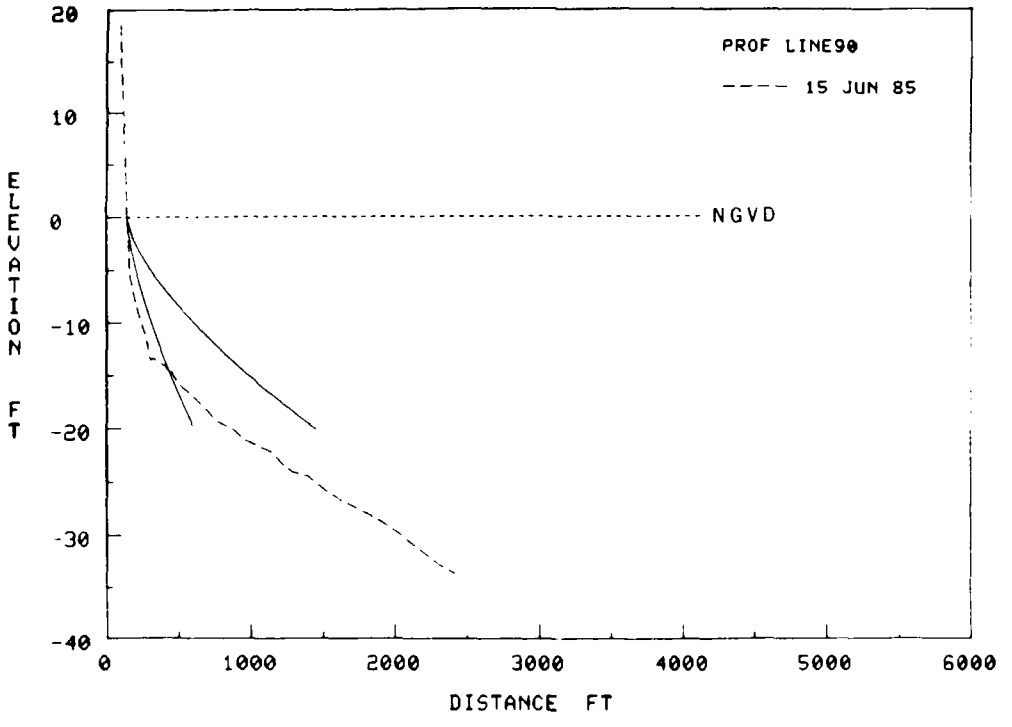
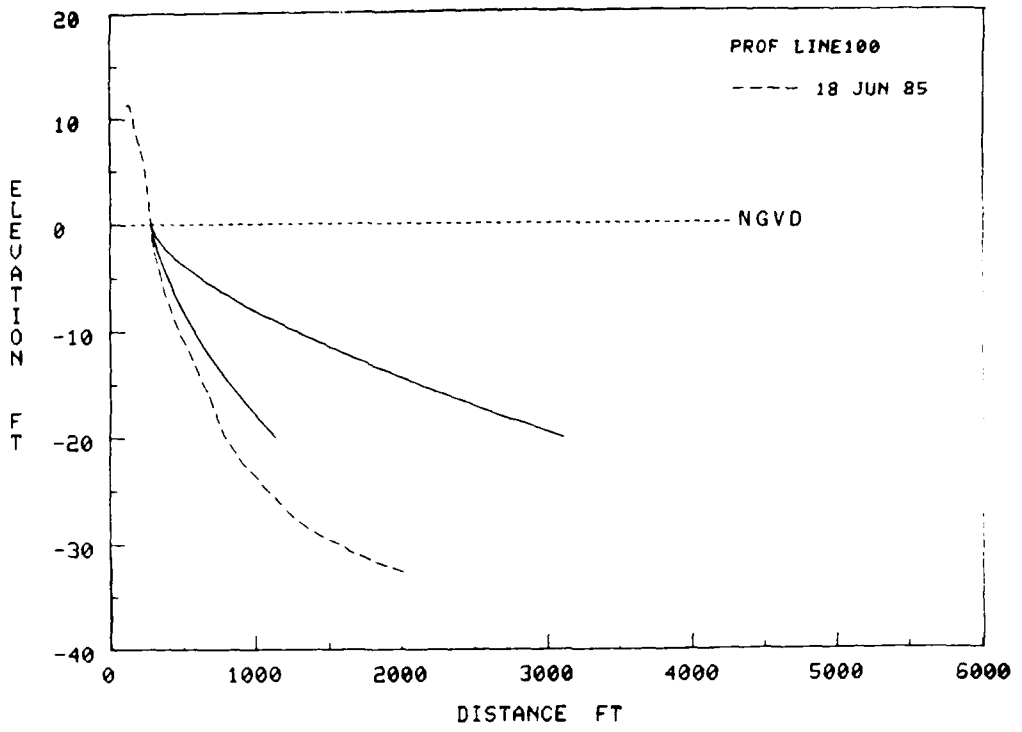


Figure D37. Profile lines 80 and 90, 1985, with equilibrium envelope



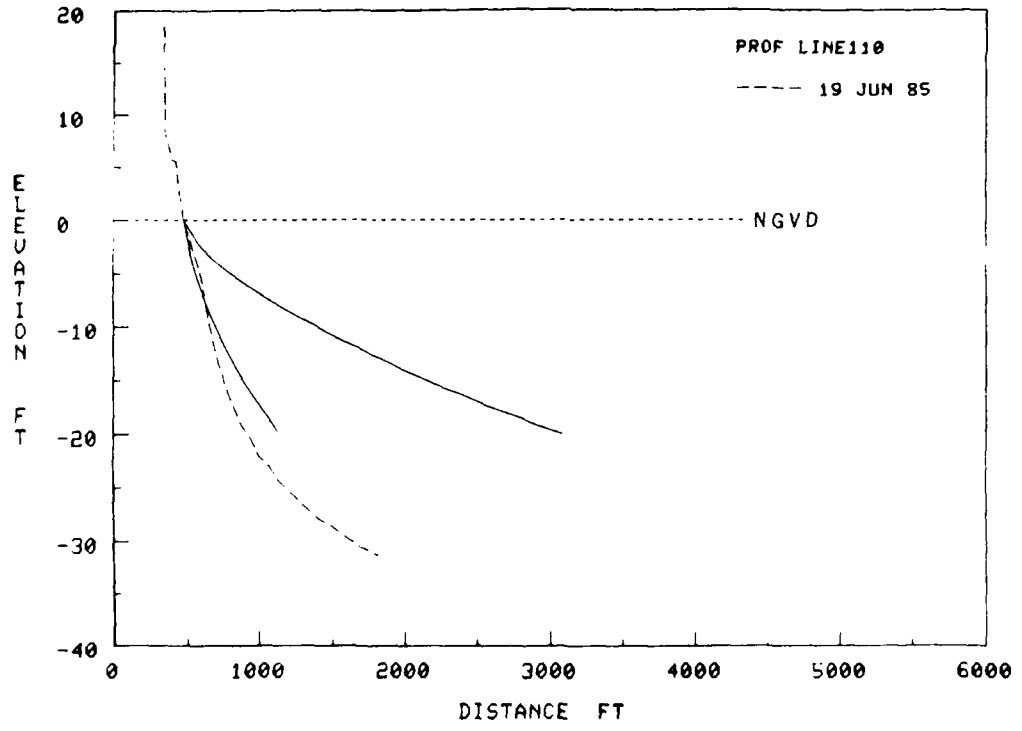


Figure D38. Profile lines 100 and 110, 1985, with equilibrium envelope

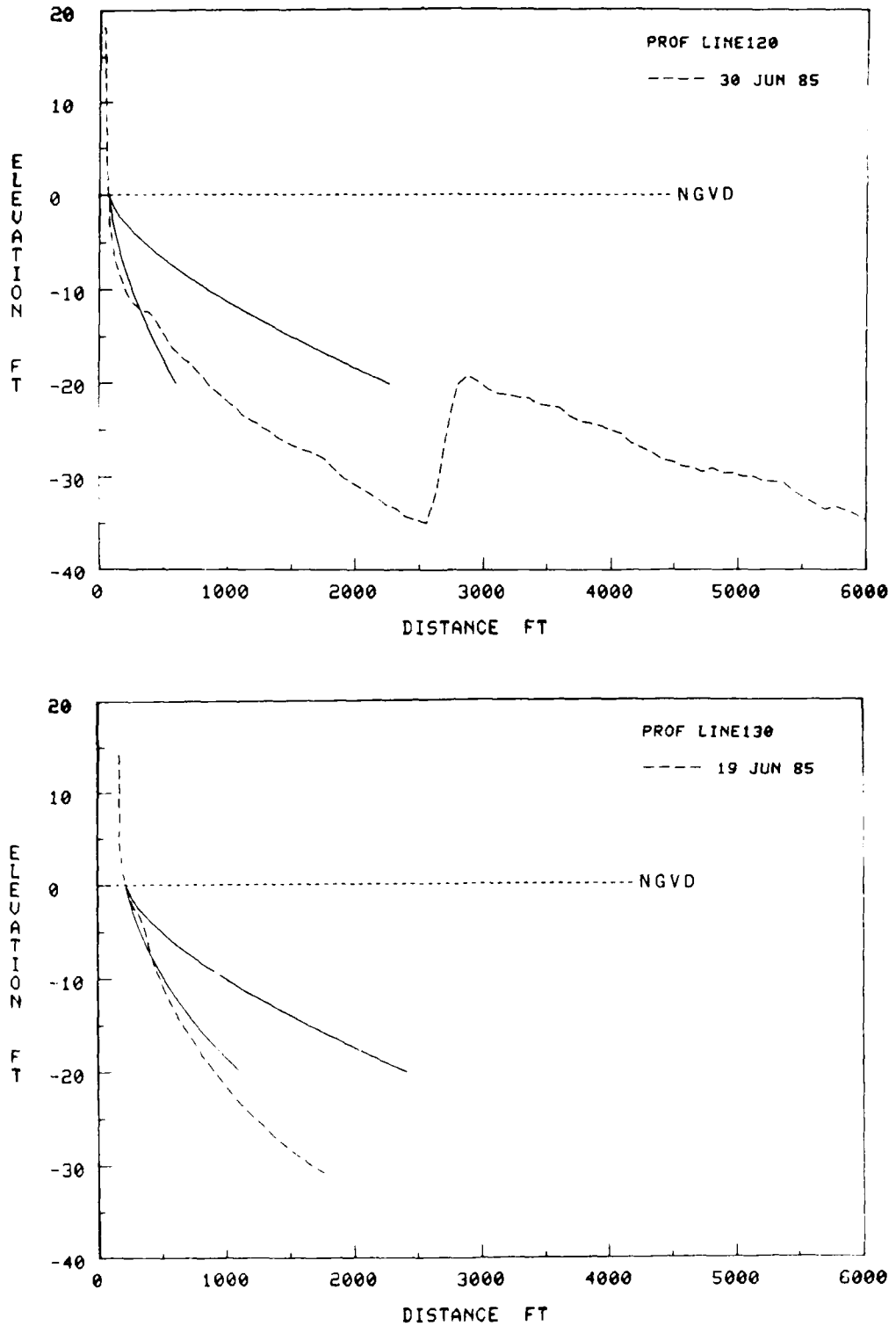
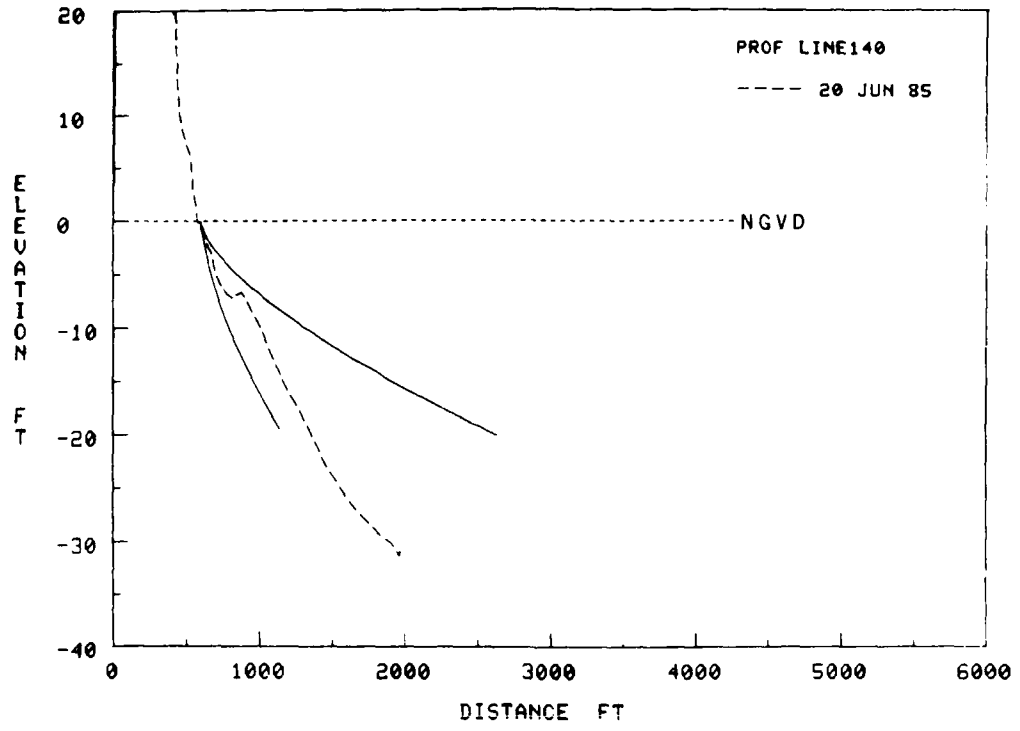


Figure D39. Profile lines 120 and 130, 1985, with equilibrium envelope



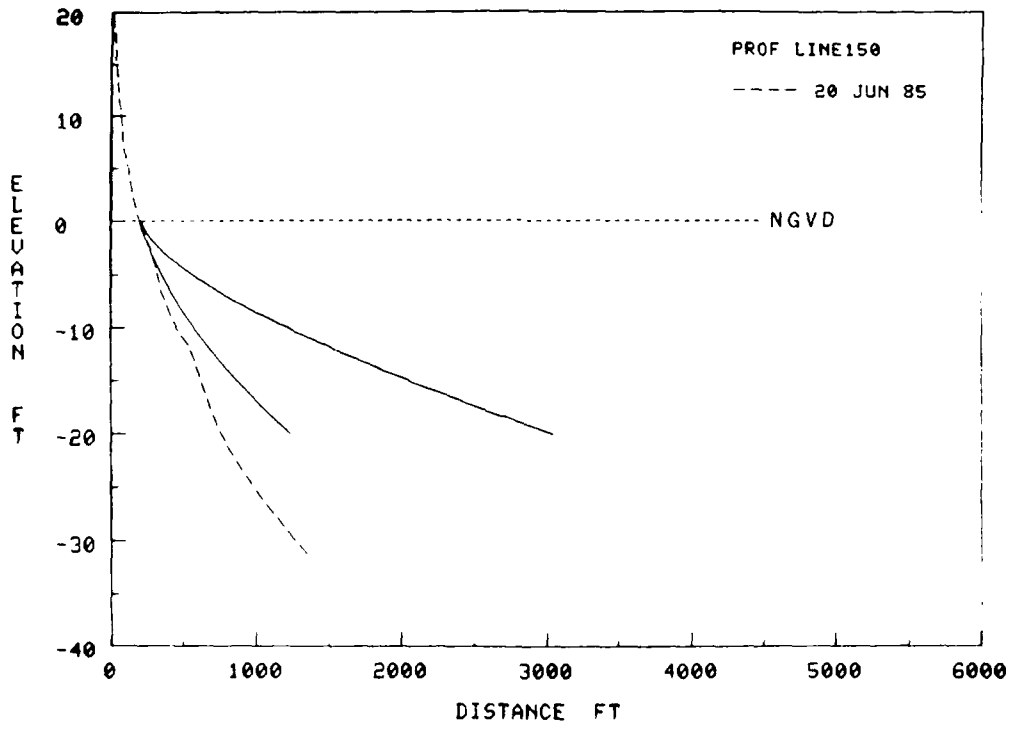
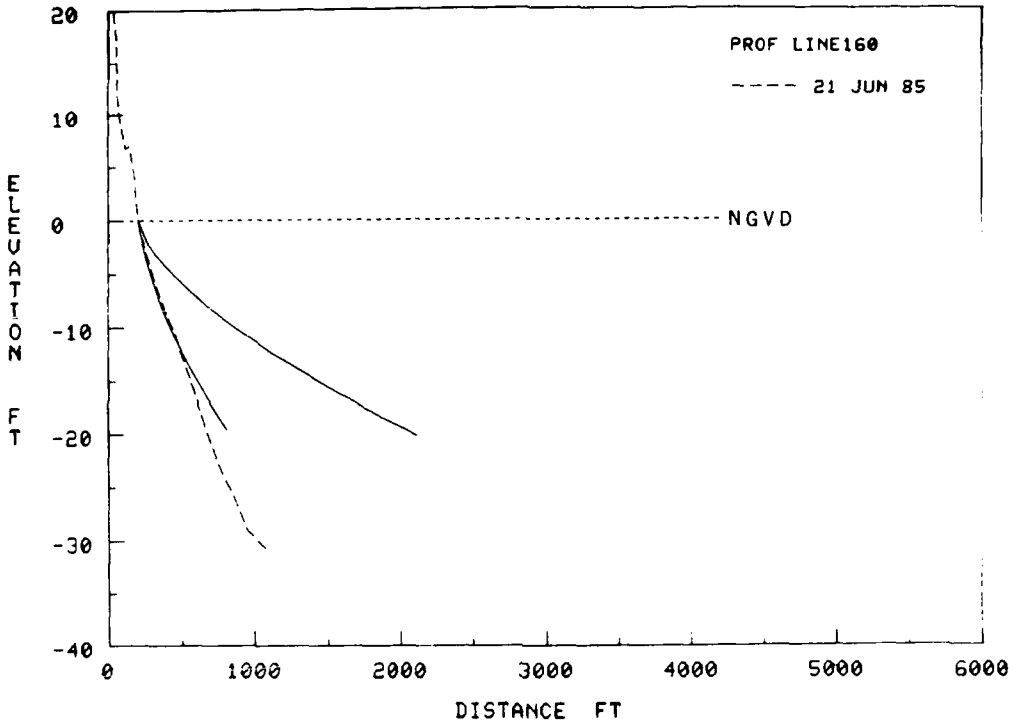


Figure D40. Profile lines 140 and 150, 1985, with equilibrium envelope



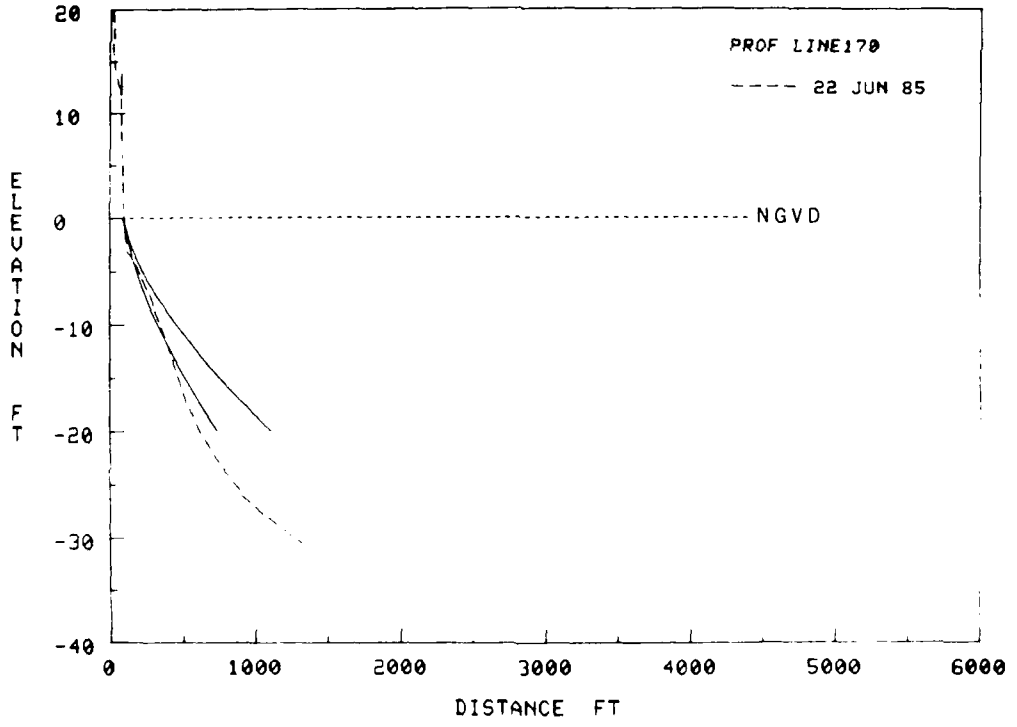
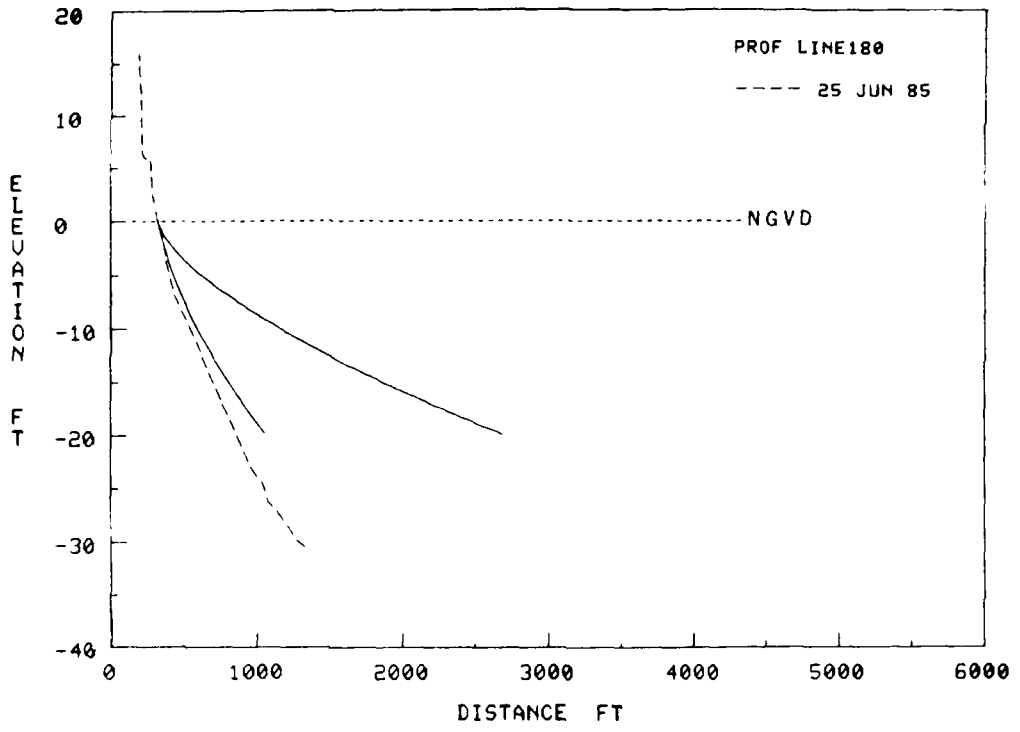


Figure D41. Profile lines 160 and 170, 1985, with equilibrium envelope



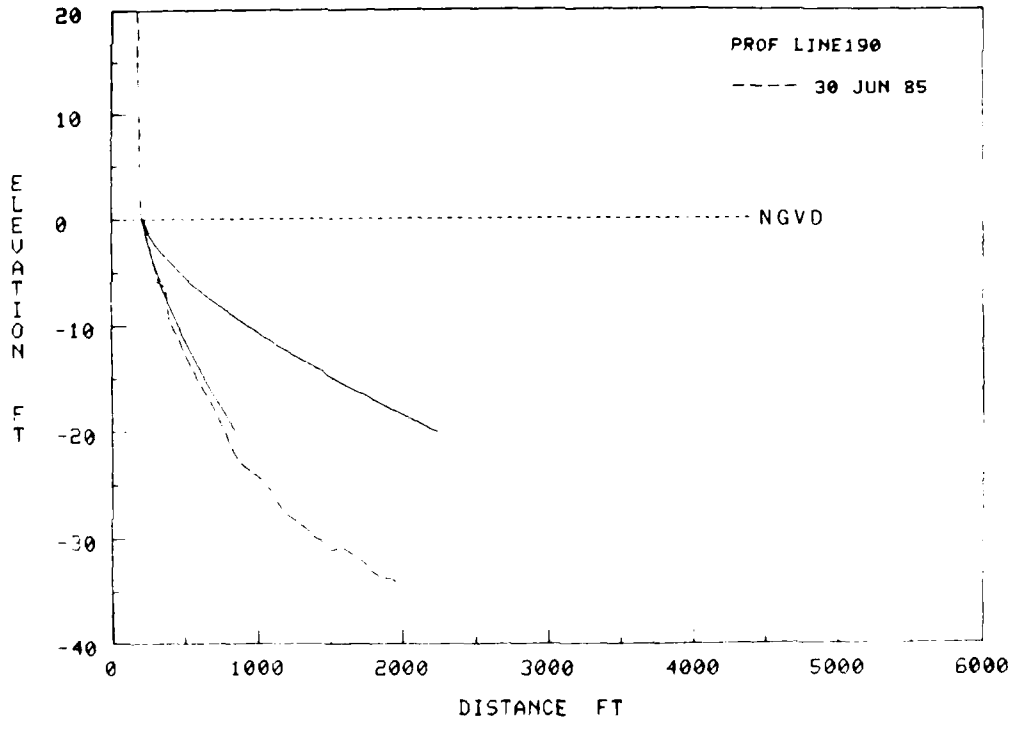
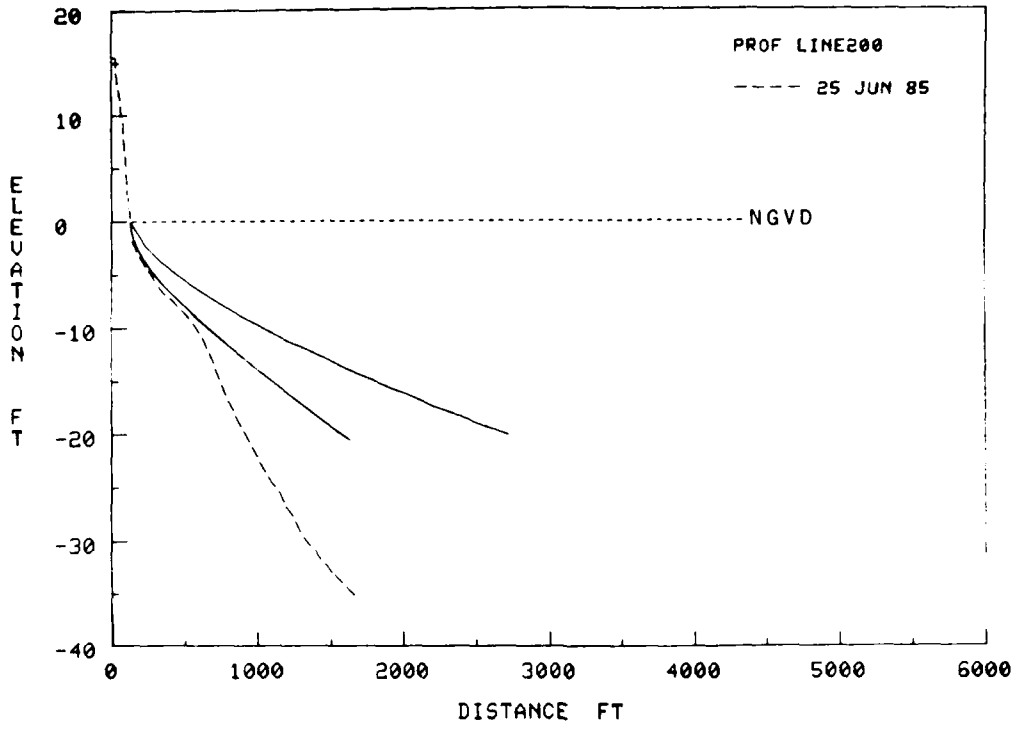


Figure D42. Profile lines 180 and 190, 1985, with equilibrium envelope



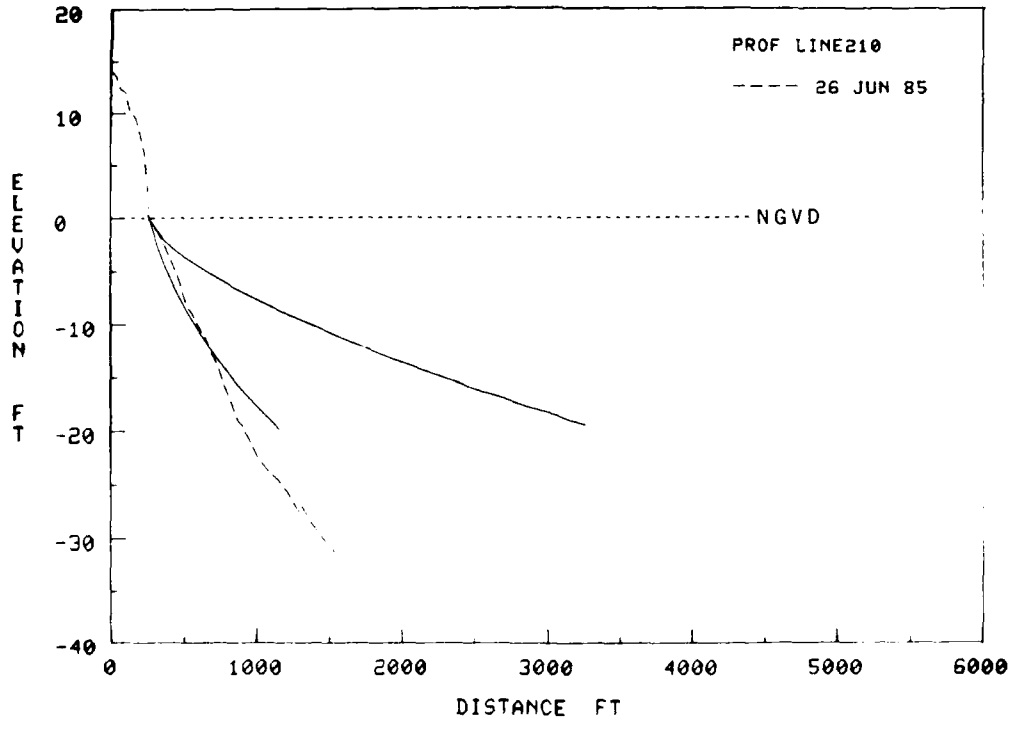
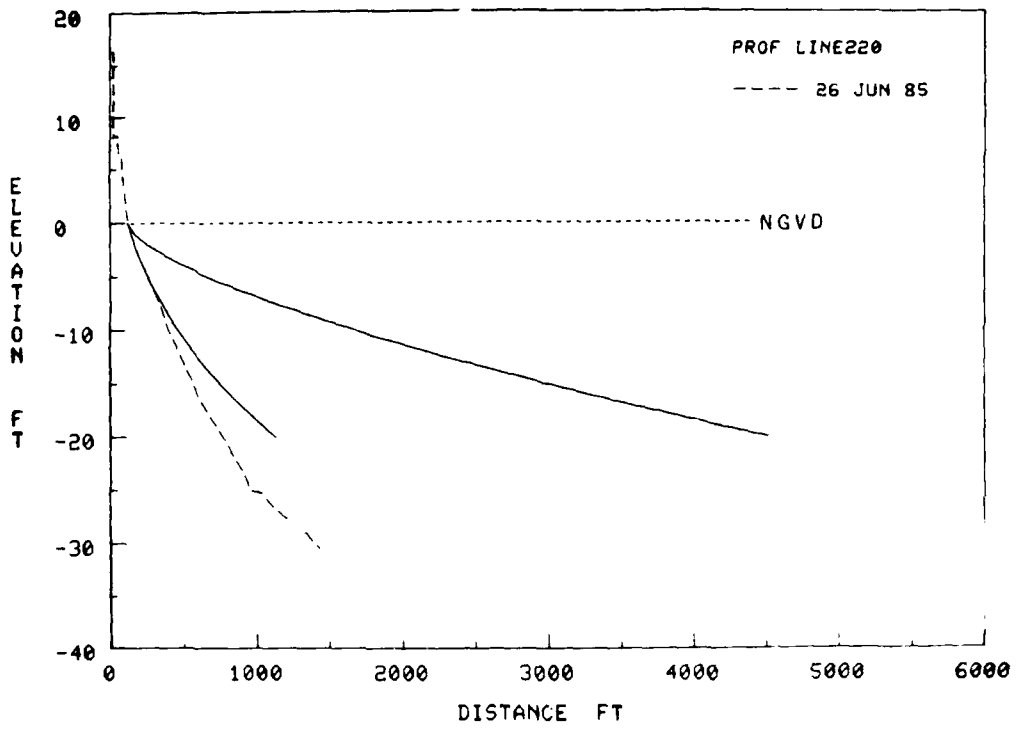


Figure D43. Profile lines 200 and 210, 1985, with equilibrium envelope



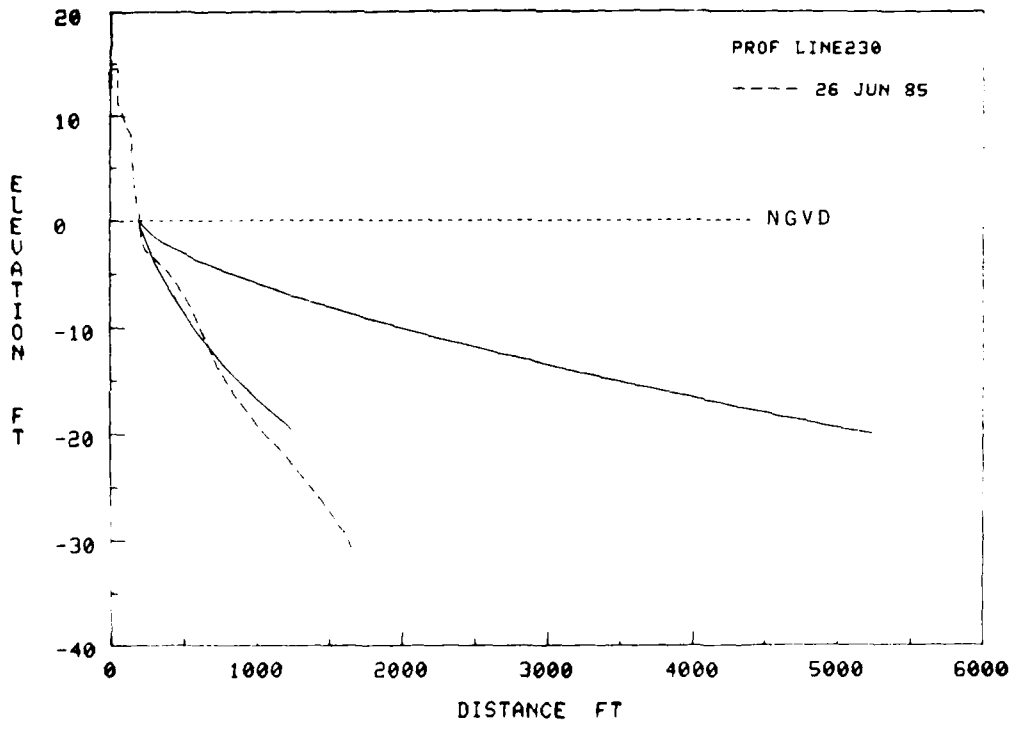


Figure D44. Profile lines 220 and 230, 1985, with equilibrium envelope

APPENDIX E: OPEN-OCEAN BORROW SITES

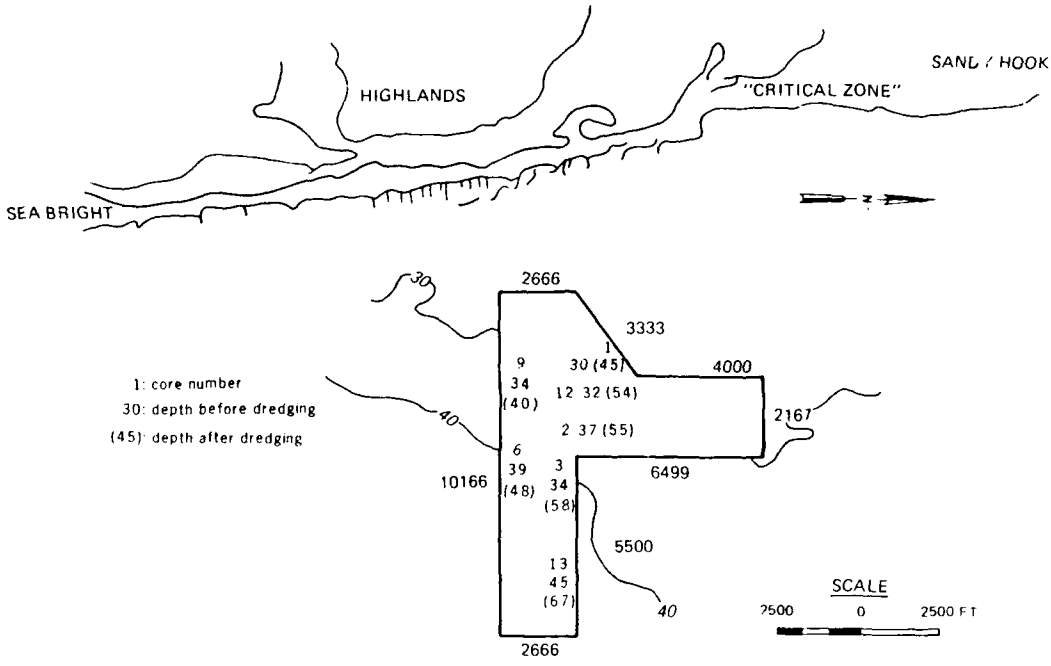
1. This appendix provides background information on vibracore data used to specify hypothetical design depths of sand removal from offshore beachfill borrow sites. An estimated depth of the borrow holes as a function of location was required in order to modify the bathymetry grid used by the wave refraction numerical model. A comparison and discussion of nearshore wave patterns calculated for the original bathymetry and bathymetry as modified by sand dredging are given in Part III of the main report. Plots of calculated refracted wave height and direction as modified by the borrow site holes are given in Appendix F, and general information on beach grain size and measured beach profiles is compiled in Appendix D.

2. CENAN (CE 1984, p 50) originally identified locations of two potential borrow sites. One site, to the northeast of the project (approximately centered at 40°24' N, 73°57' W), is a large, irregularly shaped area located approximately 1,000 ft off Sea Bright and Sandy Hook. This area will be referred to as the "northern" borrow site. It contains a large reserve of suitable sand in close proximity to the project and is considered to be an economical source of beach fill material. The location and horizontal dimensions of the northern borrow site are given in Figure 12 of the main report. Locations and identification numbers of cores taken in the immediate area of the northern borrow site are shown on Figure E1.

3. The other site discussed in the 1984 CENAN report (CE 1984, p 50) is the Sandy Hook navigation channel, located approximately 31,000 ft north of the project. This study focused on the relatively new offshore borrow sites so that the navigation channel site is not considered further.

4. A second possible open-ocean site more recently identified by CENAN is located off Belmar, south of the project area. This site, referred to here as the "southern" site, consists of two small, rectangularly-shaped areas (approximately located at 40°09' N, 73°53' W). The locations and horizontal dimensions of the southern borrow areas are shown in Figure 13 of the main report. No vibracore information could be obtained for the southern site.

5. Locations and horizontal dimensions of the northern and southern borrow sites, and locations of cores taken in the vicinity of the northern borrow site were obtained from charts contained in two seismic survey reports (Alpine Ocean Seismic Survey 1985, 1986) prepared for CENAN. Mr. Charles



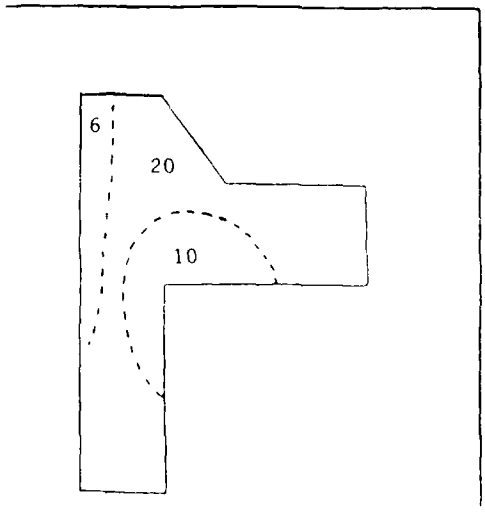


Figure E1. Maximum potential depth contours of useful beach fill material for northern borrow site

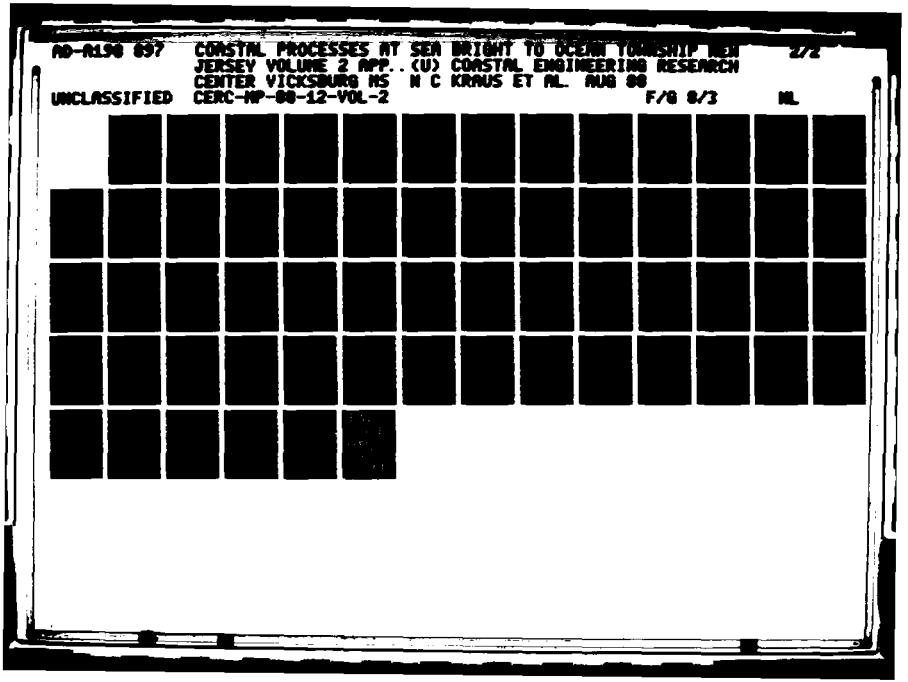
Dill, Senior Geologist, Alpine Ocean Seismic Survey, and leader of the survey cruise, provided additional interpretive information to CERC during a May 1986 meeting at CENAN and in subsequent telephone calls. Stratigraphic information was obtained from photos and visual descriptions of the vibracores contained in another report prepared under contract for CENAN (Kughler Co., Inc. undated, circa 1985).

6. Northern site. A summary of pertinent information obtained from the seven cores taken at the northern borrow site is given in Table E1. Maximum potential dredging depth in various regions of the borrow area was estimated by CERC under the assumptions that sediments of grain size ranging from fine sand to gravel would be utilized for the beach fill, and that large quantities of silt would not be mined. Maximum potential depths are listed in Table E2, and the resultant interpreted contours of potential depth of useful beach fill material are indicated on Figure E1. Core profile data were used to identify three regions with associated maximum borrow depths of 6 ft, 10 ft, and 20 ft. Dredging deeper than these depths in the respective regions would yield fill of poor quality.

7. It is economically advantageous for dredging equipment to remain on site at a fixed location in order to remove bottom material to the maximum permissible depth. However, it is recognized that the wave refraction pattern might be adversely affected by large perturbations in the bathymetry as caused by dredging to the maximum depth in the relatively shallow depth at the northern borrow site. Therefore, three dredging plans were devised for investigation of refraction patterns, with the depth of material removed differing between plans. The potential volume of beach fill made available for each plan was also estimated. The dredging plans and fill volumes are given in Table E3.

8. It has been estimated that approximately 17,000,000 cu yd of fill are required for the first phase of the shore protection project. Each of the plans in Table E3 provides considerably more material than will initially be required.

9. Southern site. The southern borrow site is believed to contain a limited amount of economically suitable beachfill material. Low mounds of fine sand lie on a bottom of fine sand and silty clay. The bathymetry in the area is highly irregular (Figure 13 in the main report). The greater depth of the southern site reduces the influence a dredged hole might have on the


AD-A190 897 COASTAL PROCESSES AT SEA BRIGHT TO OCEAN TOWNSHIP NEW 2/2
JERSEY VOLUME 2 APP.. (U) COASTAL ENGINEERING RESEARCH
CENTER VICKSBURG MS N C KRAUS ET AL. AUG 88
UNCLASSIFIED CERC-MP-88-12-VOL-2 F/G 8/3 NL

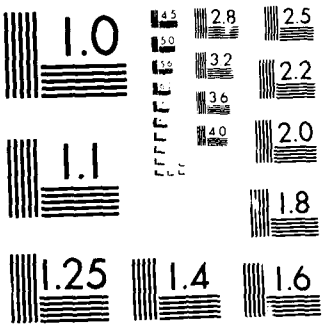

1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0

Table E1

Summary of Cores Taken at the Northern Borrow Site

Core No.	Core Location (NJ Trans. Mer.*)	Water Depth (ft MLW)	Core Description	Maximum Potential Dredging Depth (ft)
1	2196128 573042	30.0	Fine to coarse sand and gravel	15.0
2	2198955 572864	36.5	Silty fine sand, coarse sand and pea gravel	18.0
3	2200003 573000	34.0	Fine to medium sand, silt and sandy gravel	24.0
6	2199090 571478	39.0	Medium to coarse sand and medium gravel	9.0
9	2197158 571705	34.0	Fine to coarse sand and medium gravel	6.0
12	2197275 573167	32.0	Medium to coarse sand	22.0
13	2200983 571997	45.0	Fine to coarse sand and gravel	22.0

* Transverse Mercator.

Table E2

Maximum Potential Depth of Borrow Material

Based on Cores Taken at the Northern Borrow Site

Core No.	Ambient Depth (ft MLW)	Maximum Borrow Depth (ft MLW)	Maximum Total Depth (ft MLW)
1	30	15	45
2	37	18	55
3	34	24	58
6	39	9	48
9	34	6	40
12	32	22	54
13	45	22	67

Table E3

Northern Borrow Site: Hypothetical Dredging Plans

Plan	Dredged Depths* (ft)	Available Volume (cu yd)
Minimum dredging	6, 6, 6	29,400,000
Intermediate dredging	6, 10, 10	45,200,000
Maximum dredging	6, 10, 20	58,500,000

* Dredged depths in three sections as given in Figure E1.

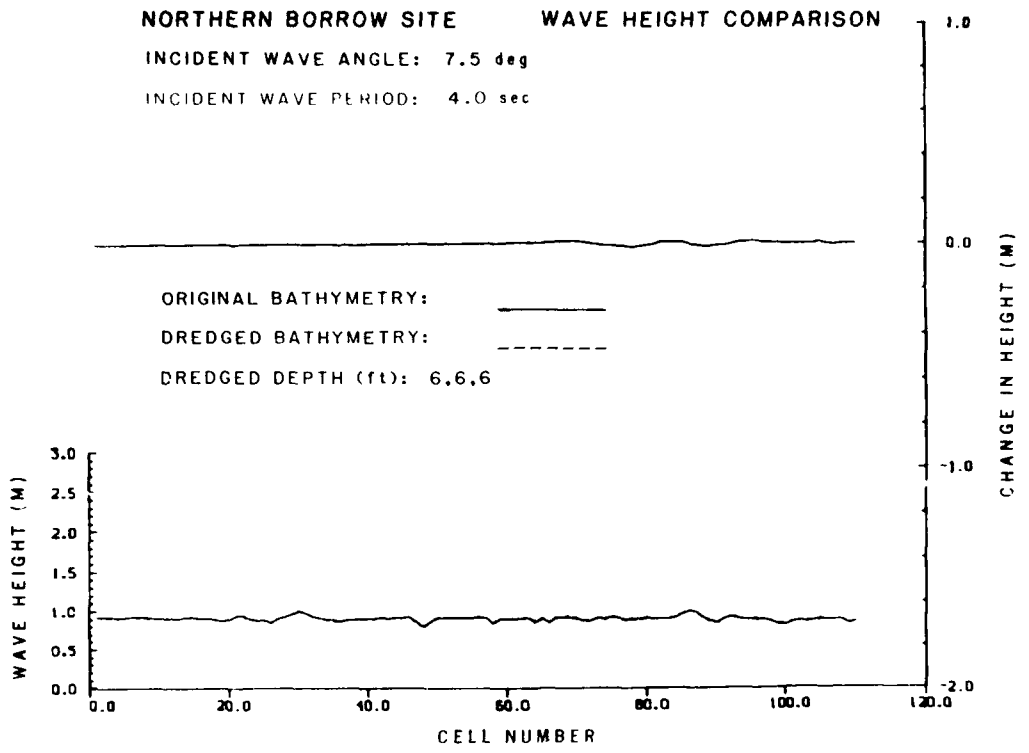
nearshore wave refraction pattern. As an estimate of the thickness of available borrow material for purposes of the refraction calculation, two dredged depths of 6 ft and 10 ft were used. The corresponding total volumes of fill are an estimated 3,950,000 cu yd and 5,800,000 cu yd.

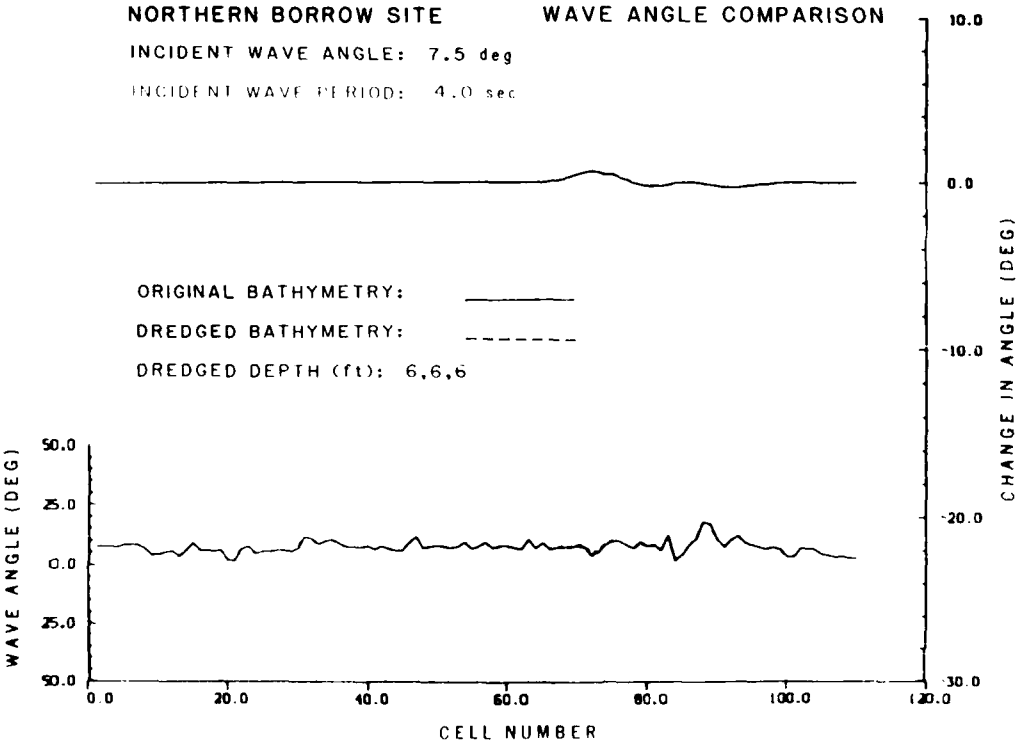
APPENDIX F: WAVE REFRACTION CHANGE AT BORROW SITES

1. This appendix provides plots of calculated change in refracted wave height and angle as modified by dredging at the potential borrow sites. The figures are arranged with the wave height comparison plot given at the top of the page and the wave angle comparison given at the bottom of the page.

2. For the northern site, three wave approach angles were used: 7.5, 22.5 and -22.5 deg (due east = 0.0 deg). For the wave approach angle of 7.5 deg, three wave periods are investigated: 4.0, 8.0, and 12.0 sec. For the wave approach angles of 22.5 and -22.5 deg, a wave period of 8.0 sec was used. Each of these cases (total of 5) was run for three idealized dredging depths. Dredged depths given for the northern site are described in Appendix E.

3. For the southern site, the same five wave conditions were run for idealized dredging depths of 6 and 10 ft.


NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER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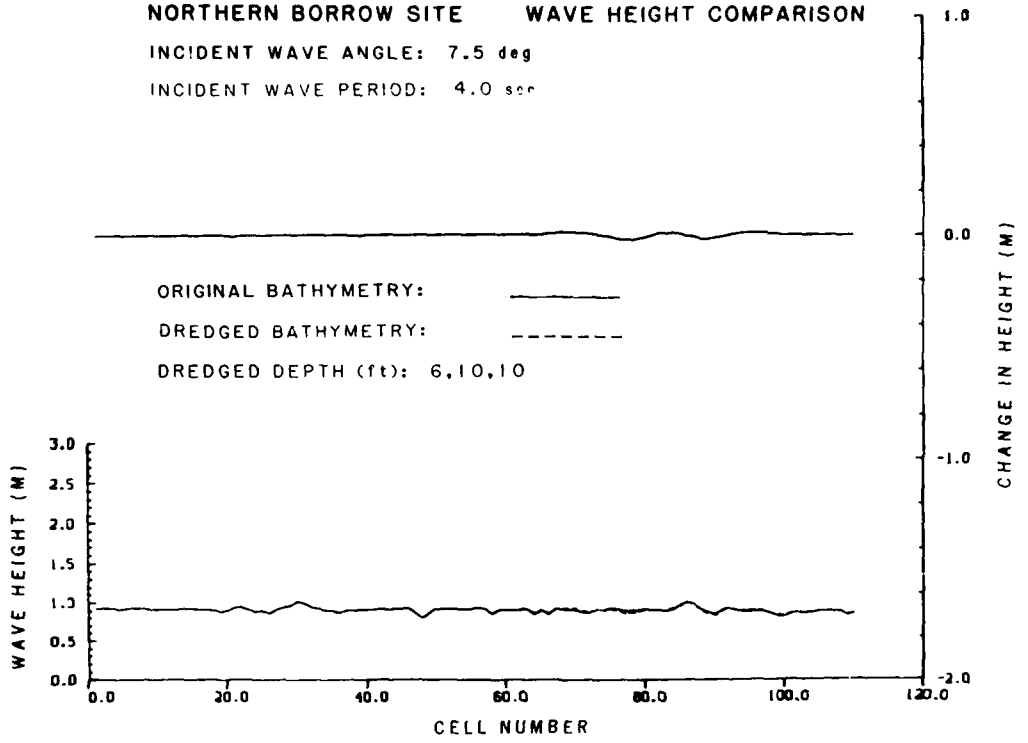
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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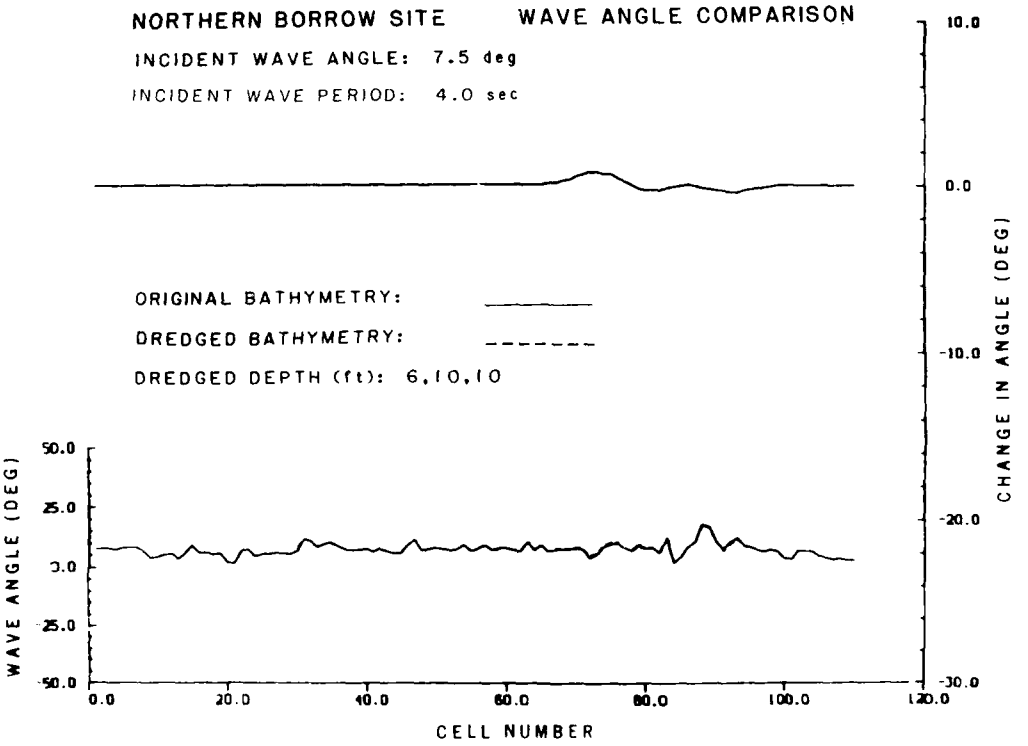
DREDGED DEPTH (ft): 6,10,10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER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INCIDENT WAVE PERIOD: 4.0 sec
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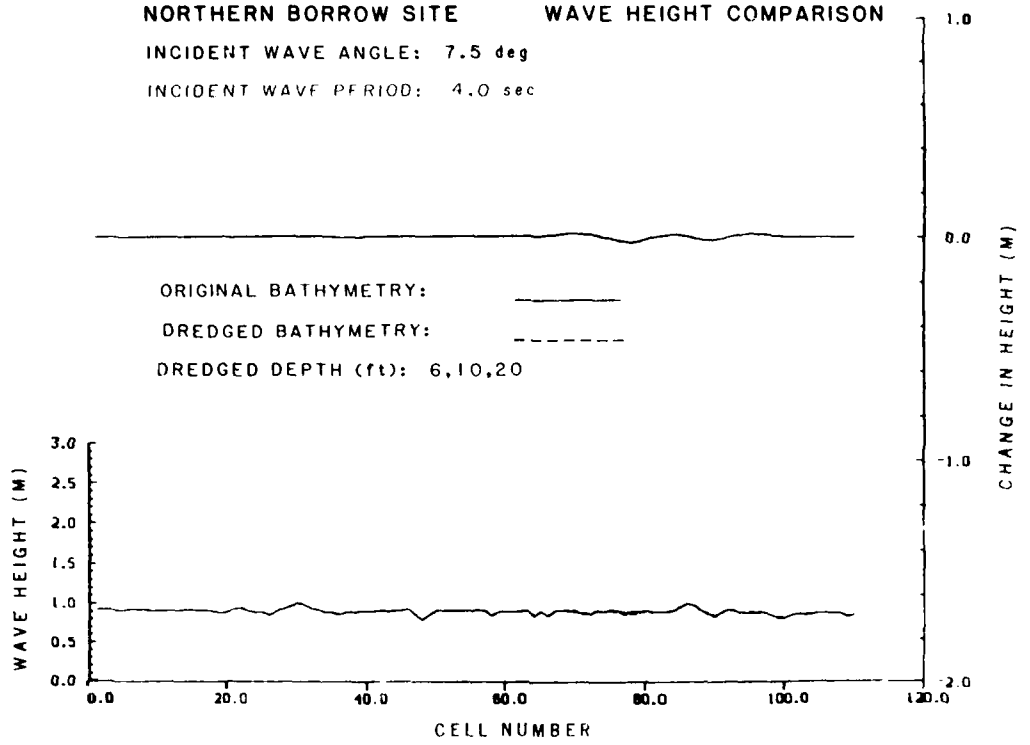
DREDGED DEPTH (ft): 6,10,10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
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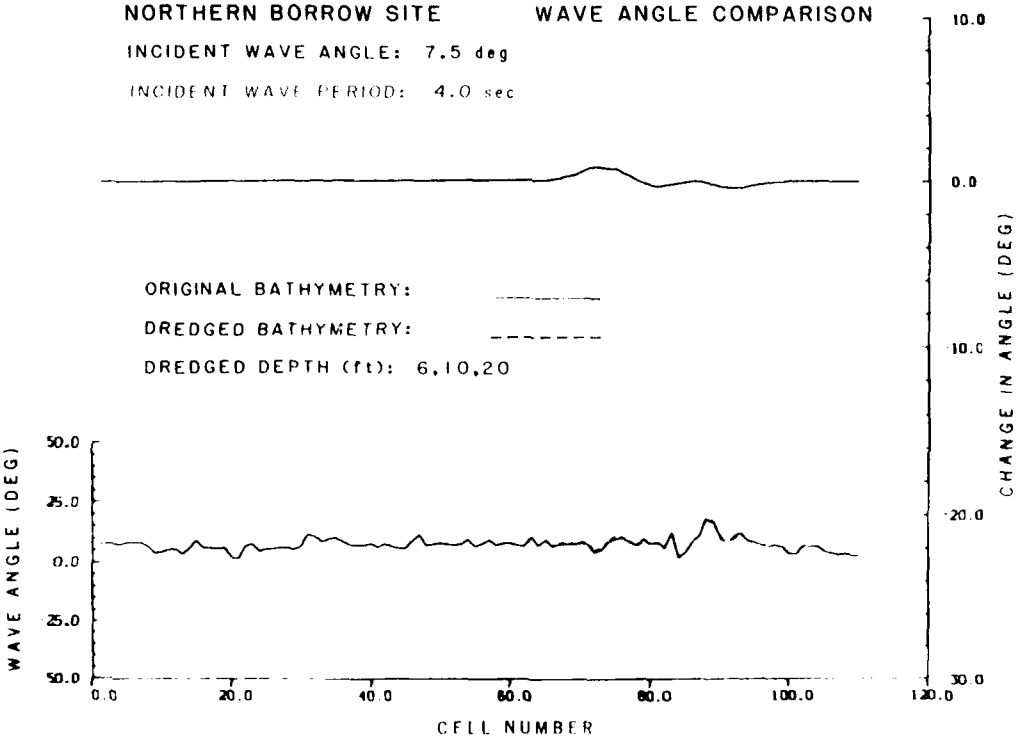
DREDGED DEPTH (ft): 6,10,20
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER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CHANGE IN ANGLE (DEG)
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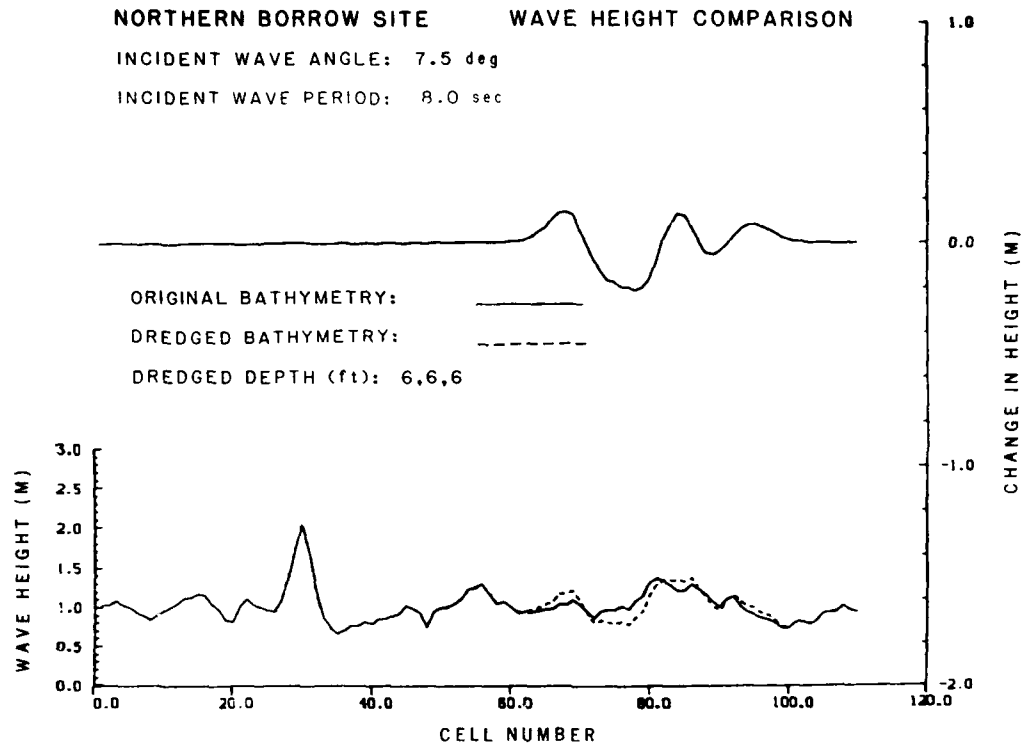
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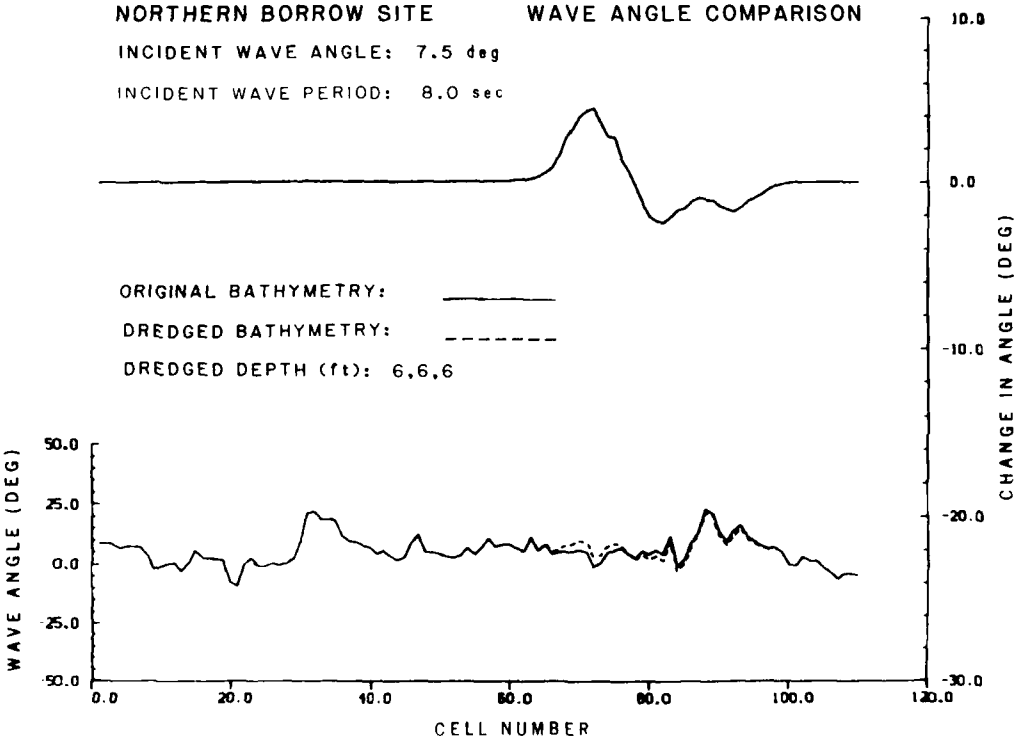
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER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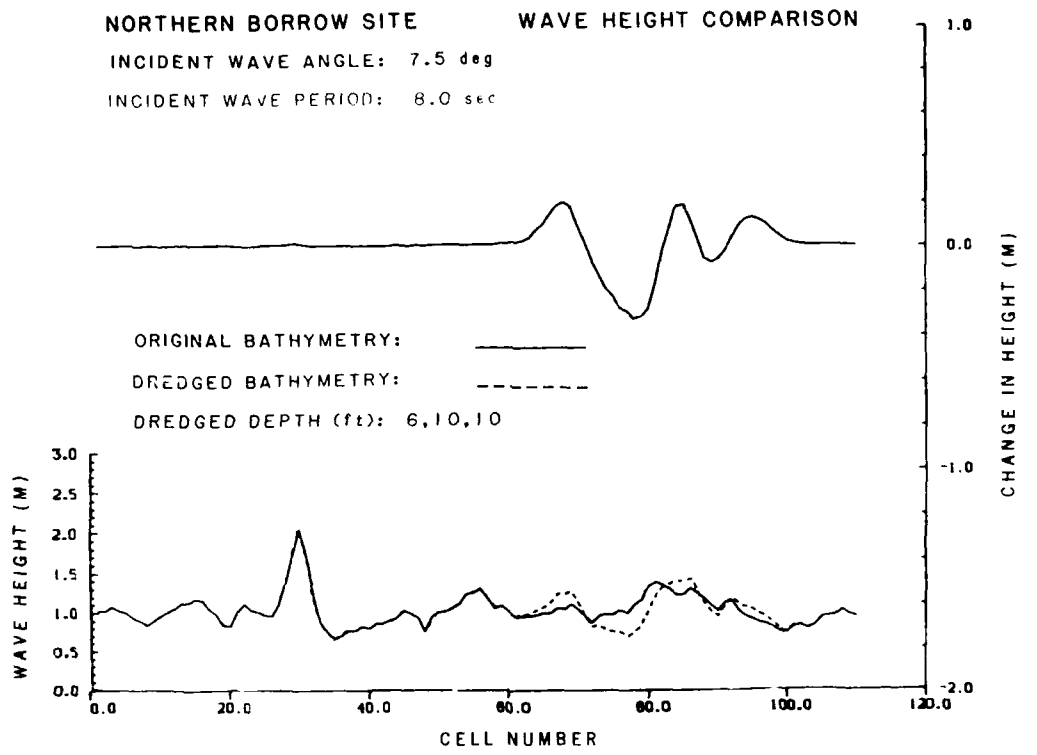
DREDGED DEPTH (ft): 6,6,6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
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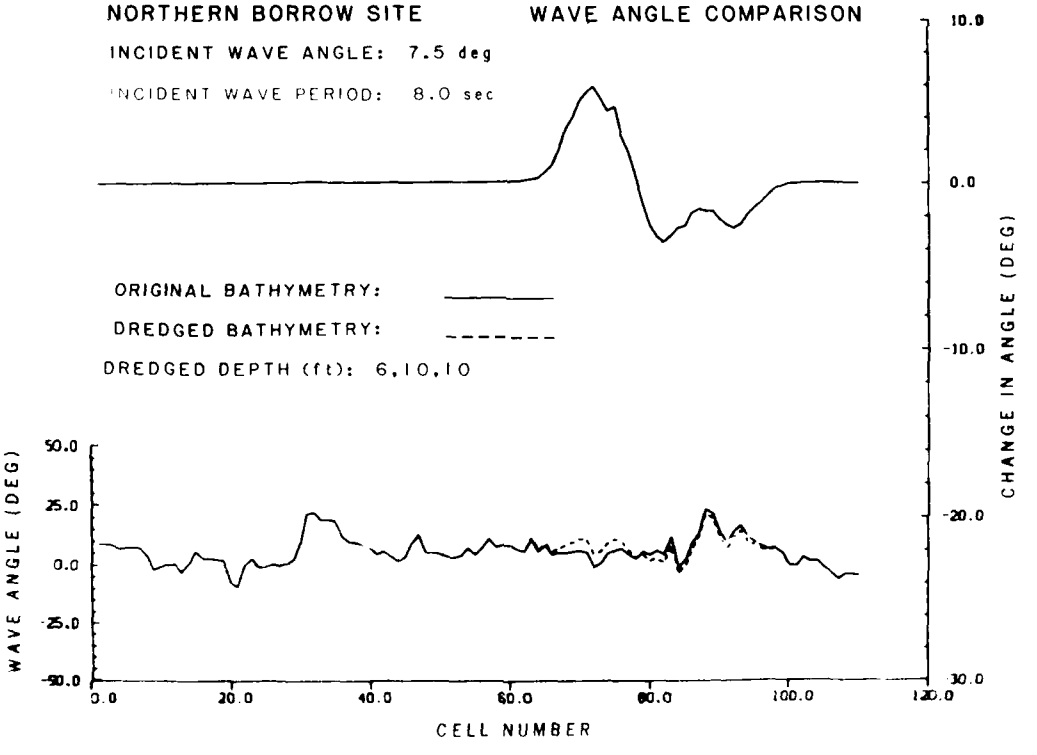
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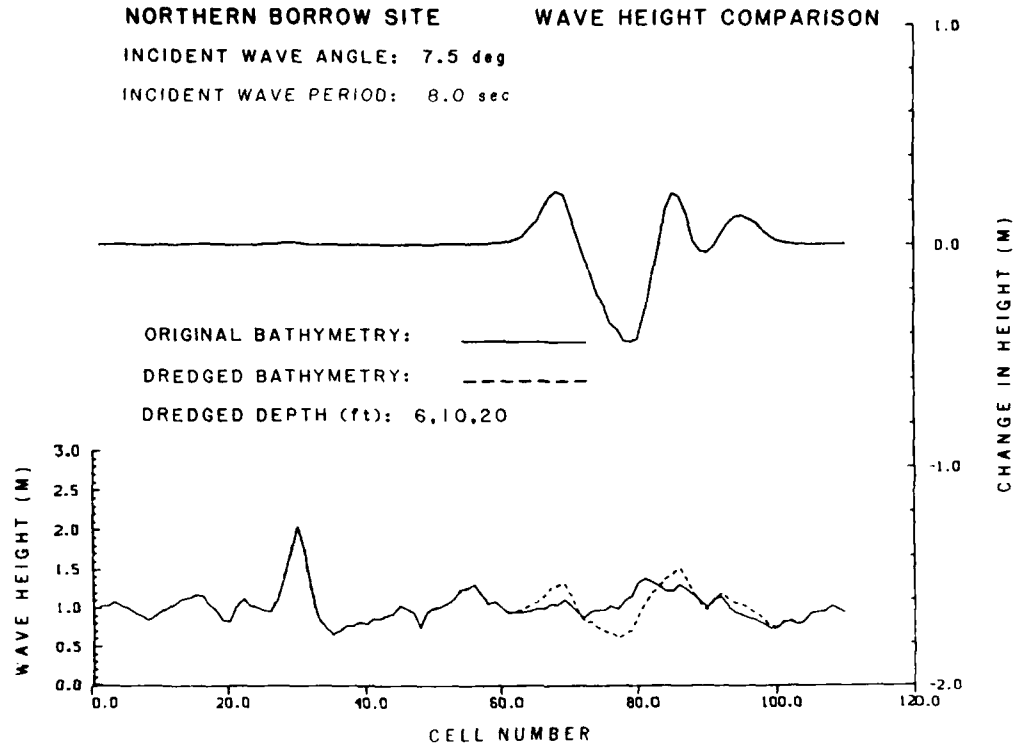
DREDGED DEPTH (ft): 6,10,10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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WAVE HEIGHT (M)
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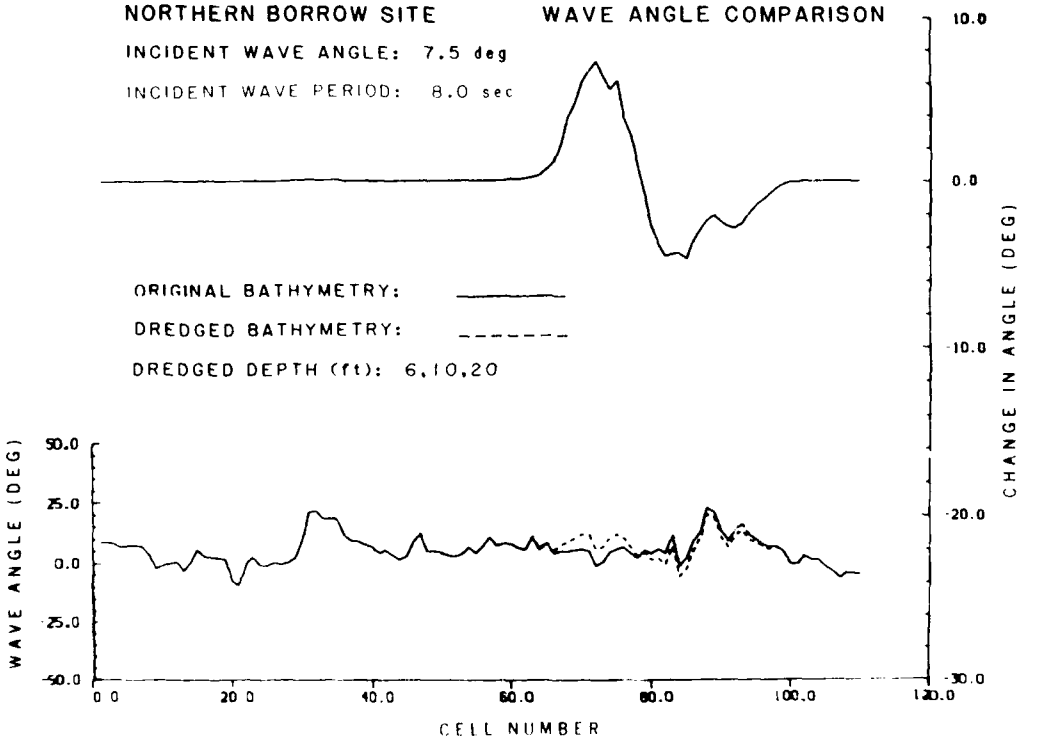
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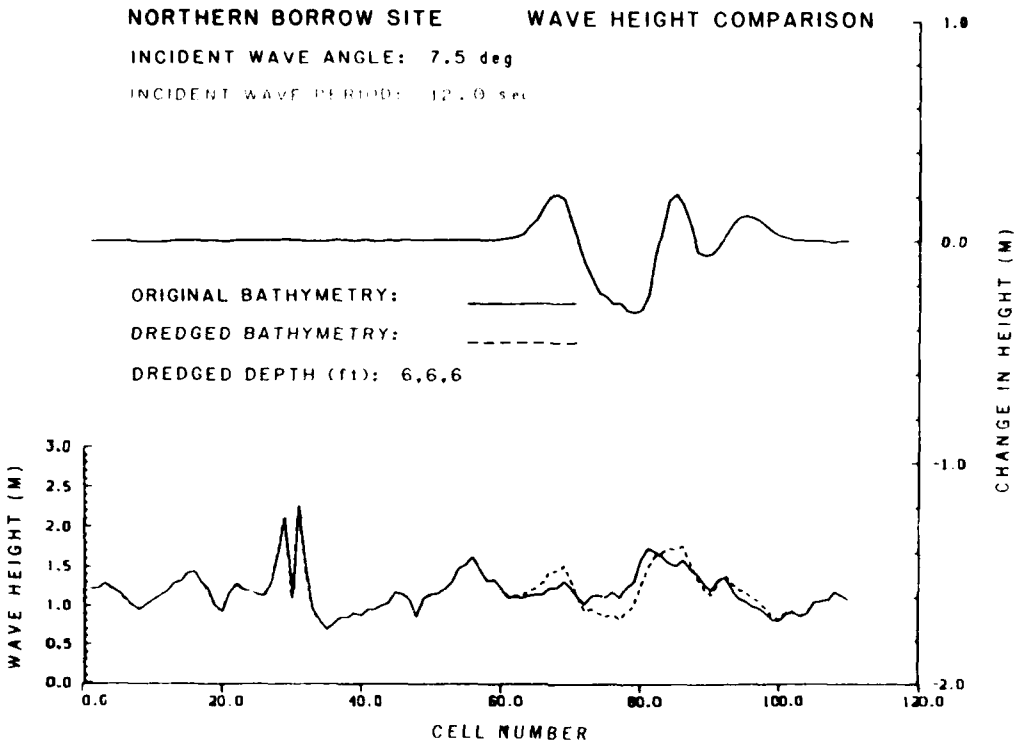
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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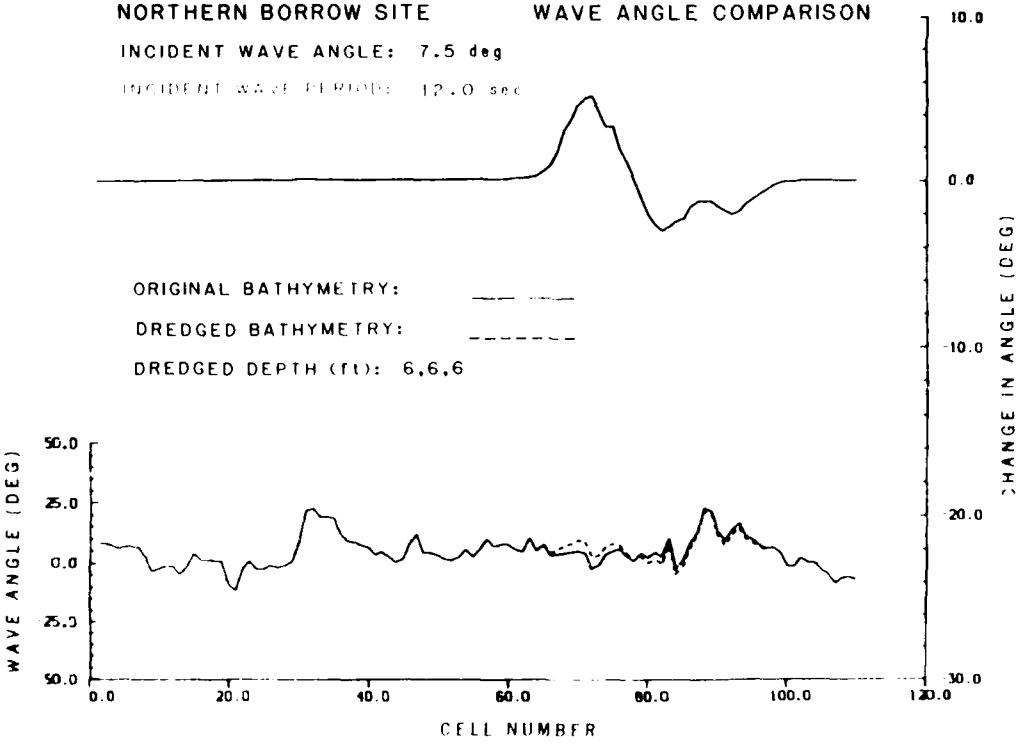
DREDGED DEPTH (ft): 6,6,6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER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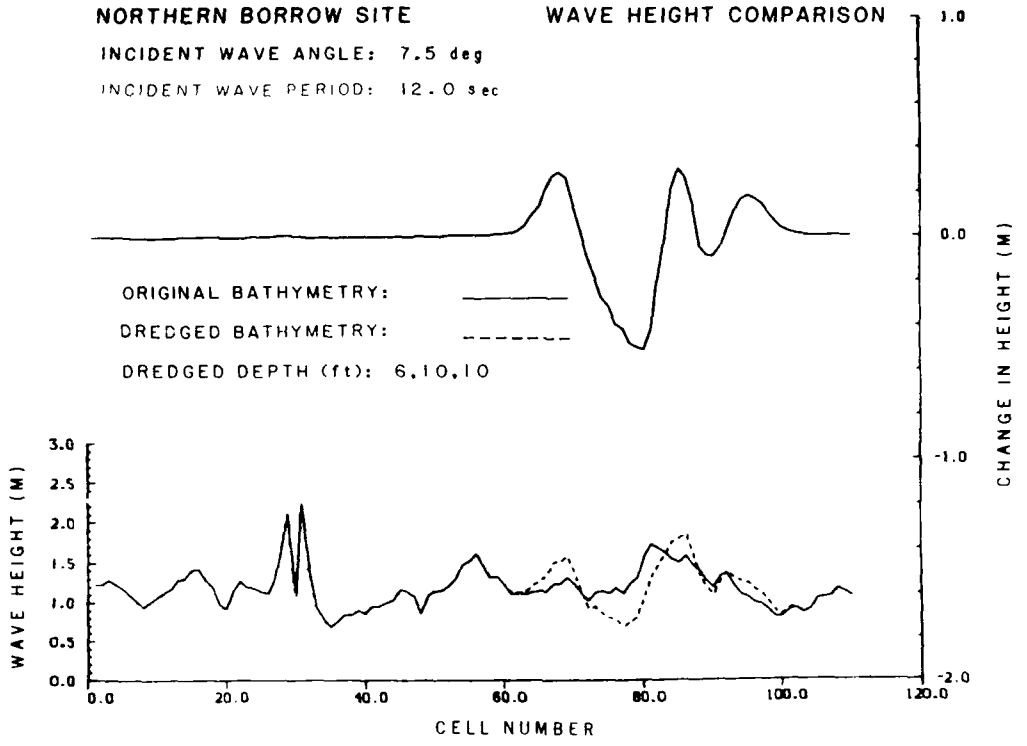
CHANGE IN ANGLE (DEG)
CELL NUMBER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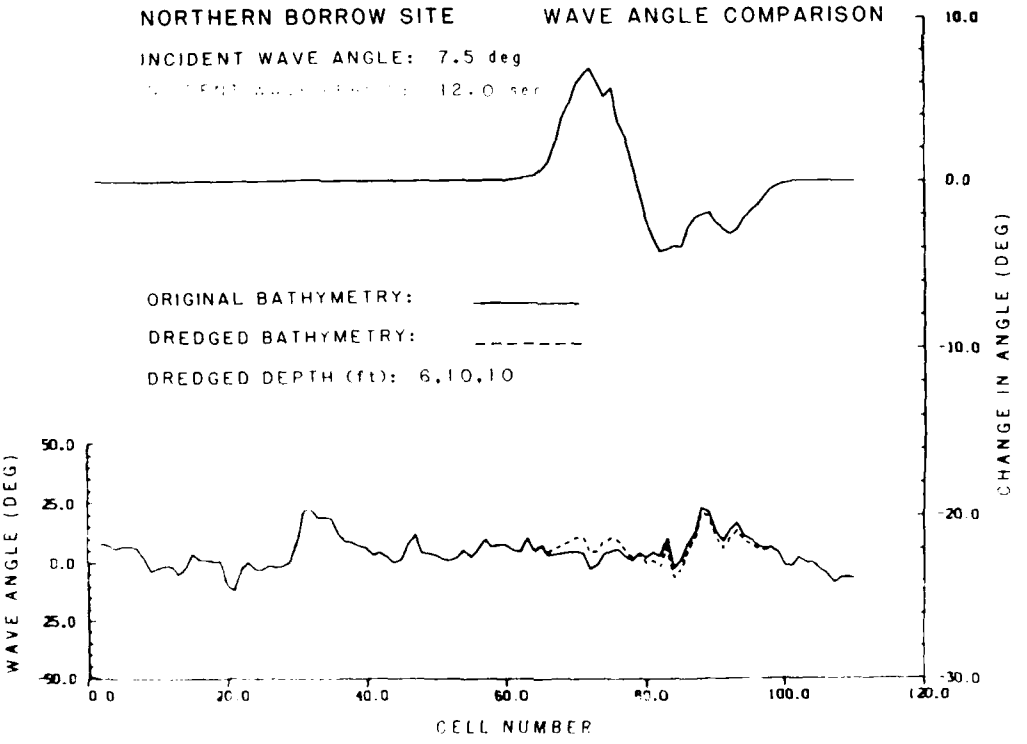
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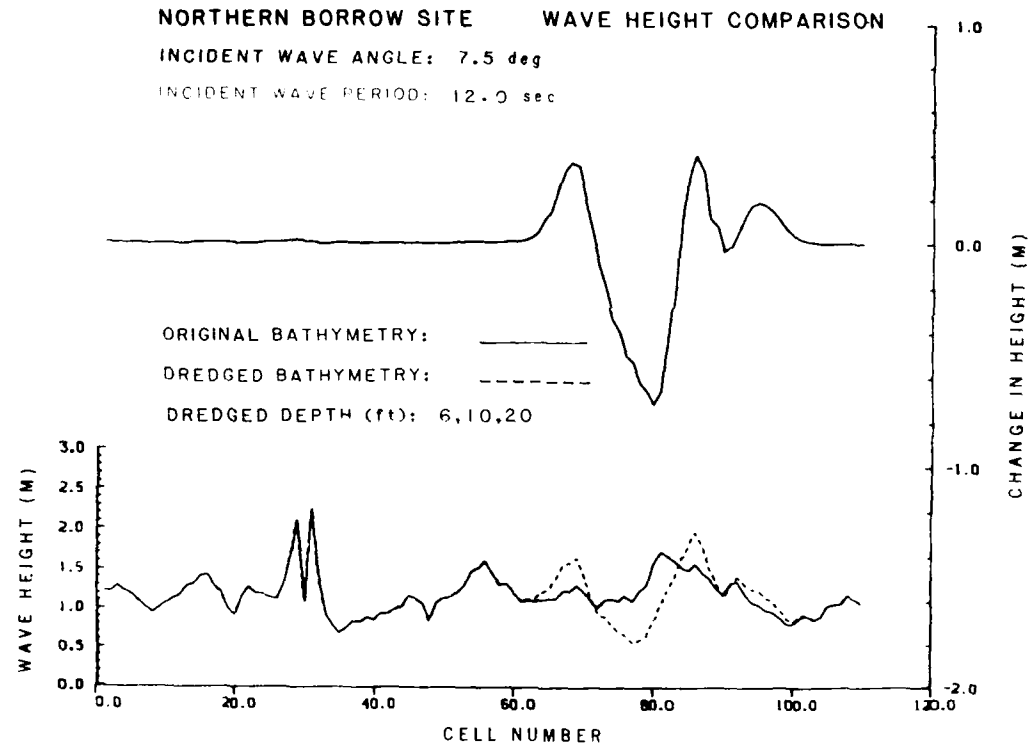
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER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WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
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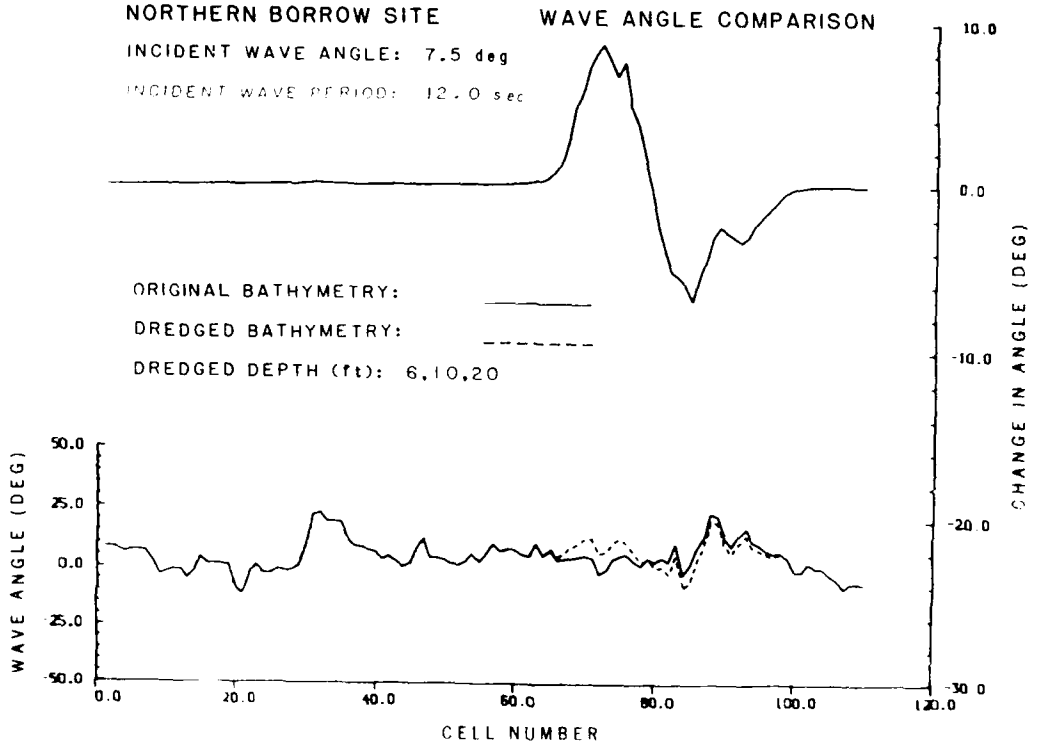
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INCIDENT WAVE PERIOD: 12.0 sec
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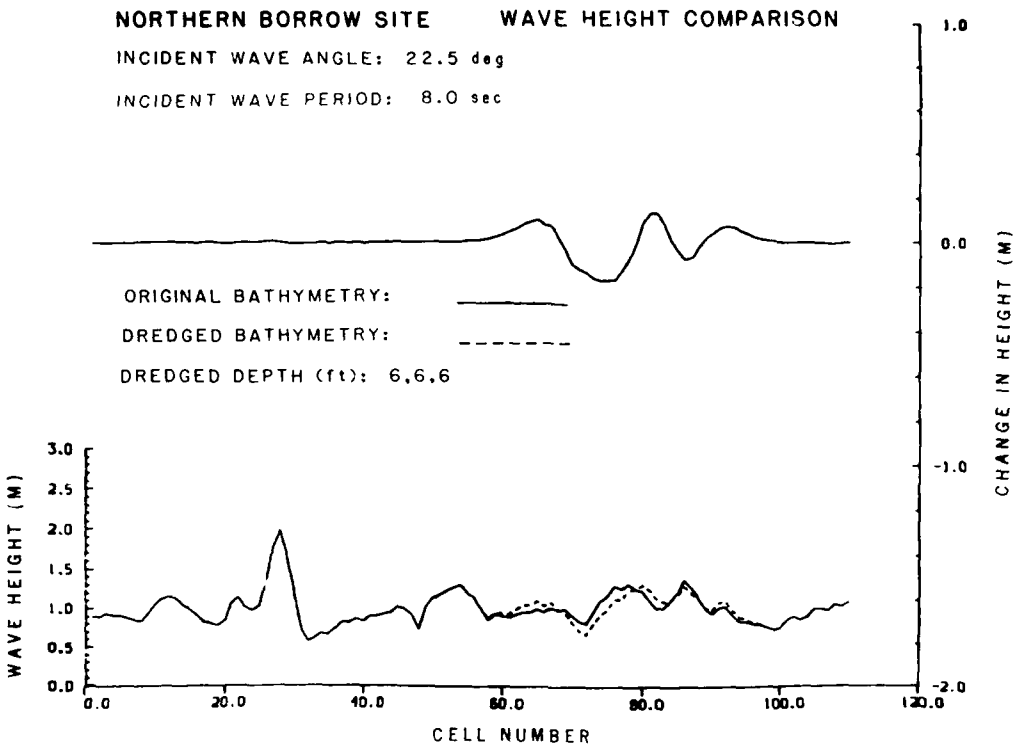
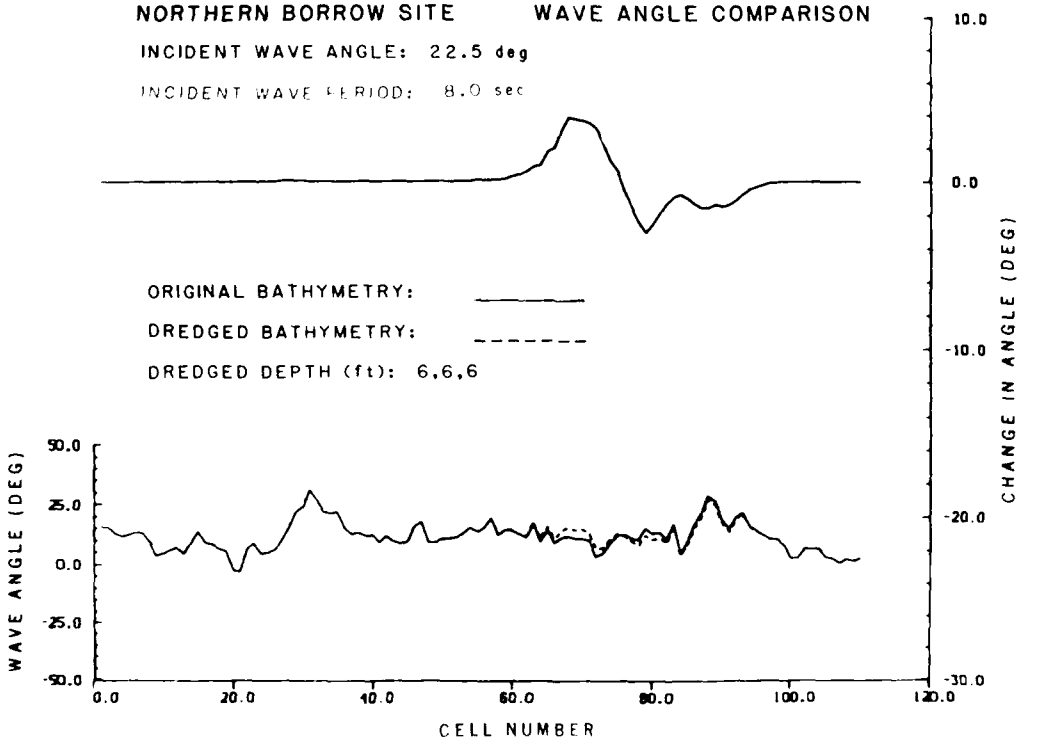
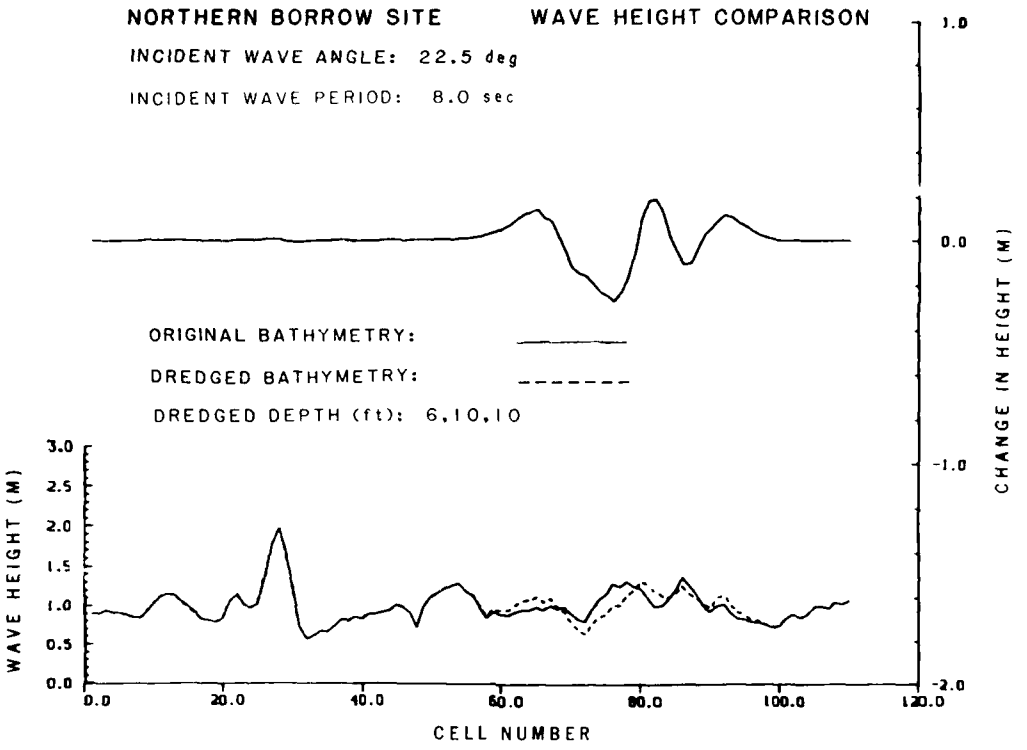
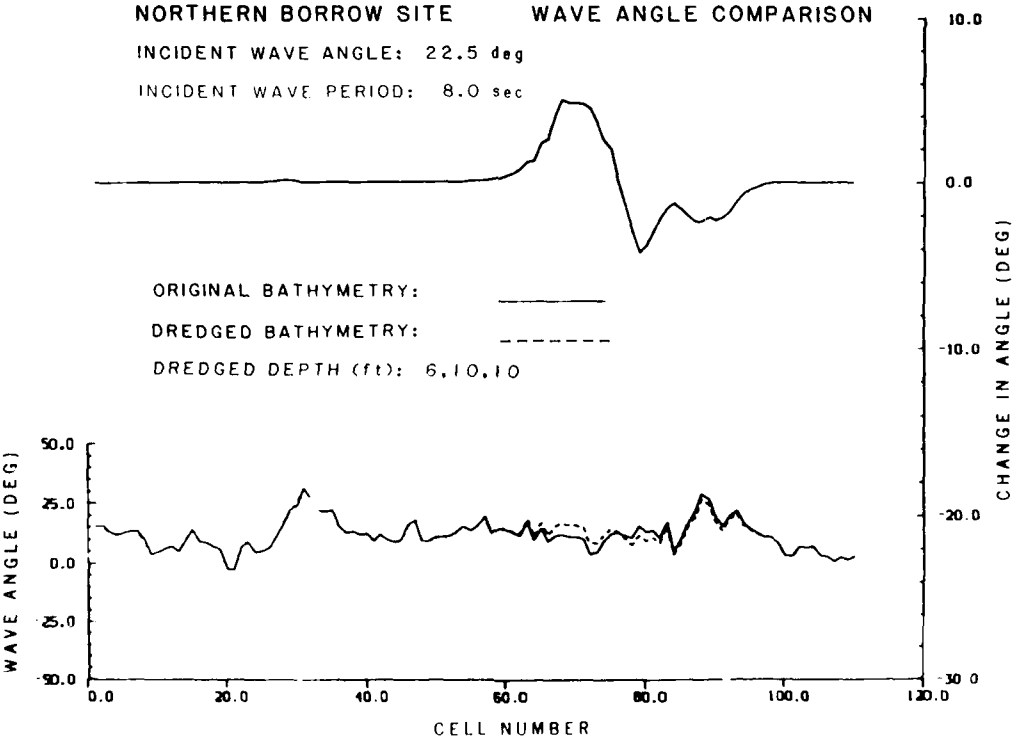
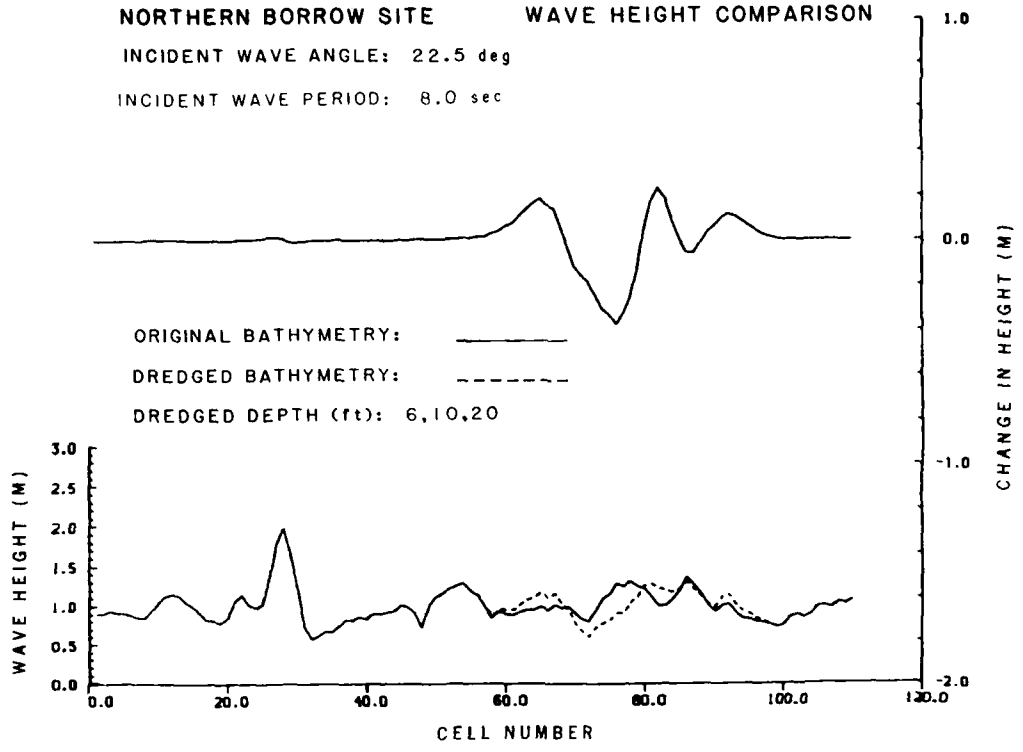
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,20
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER

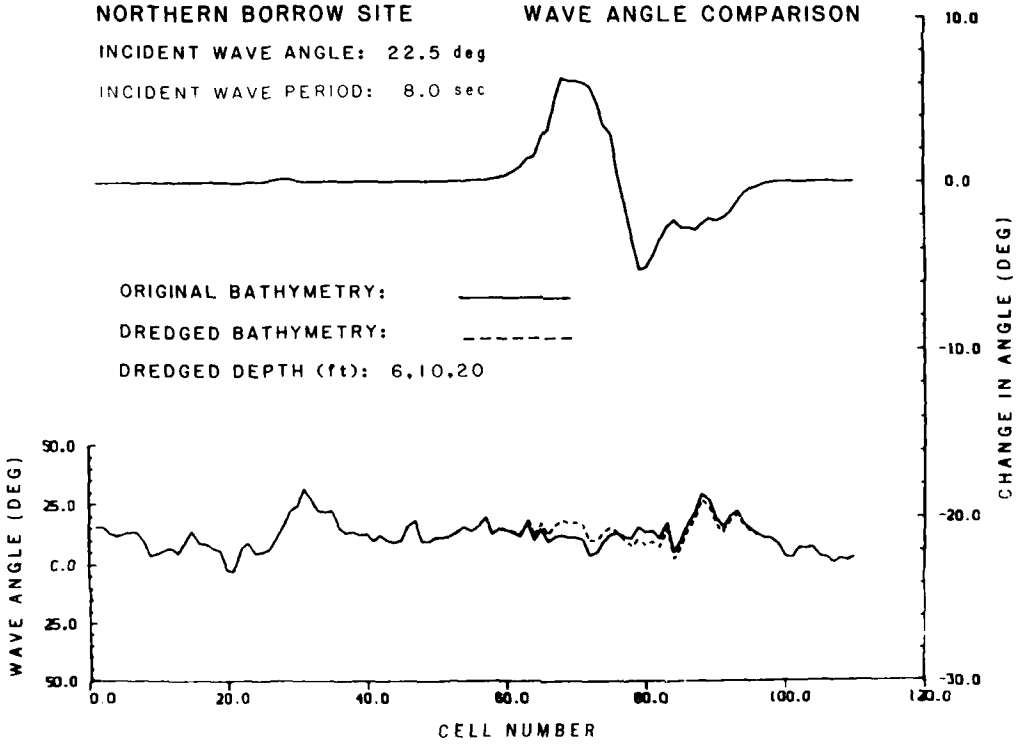

NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER

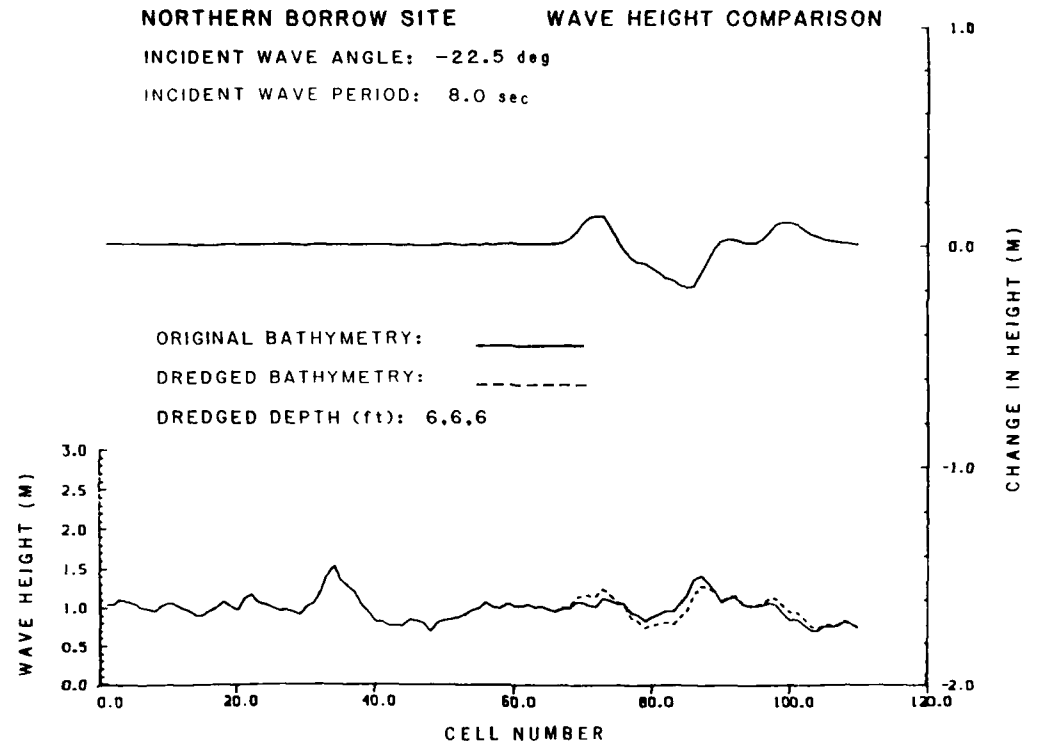

NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER

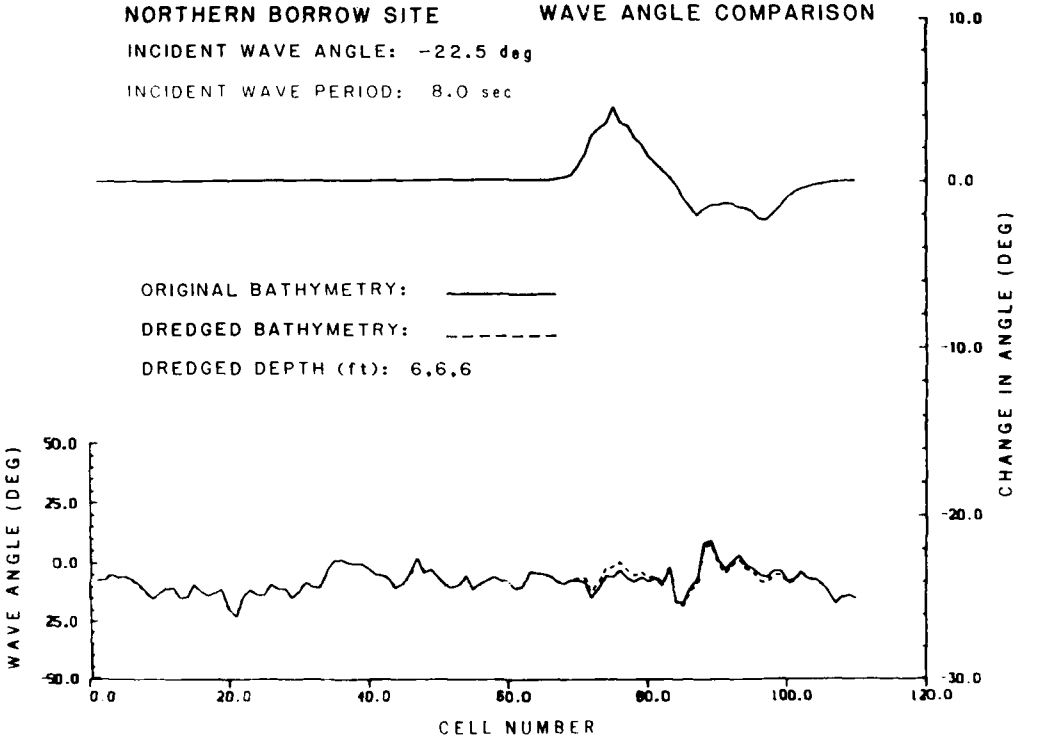

NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER

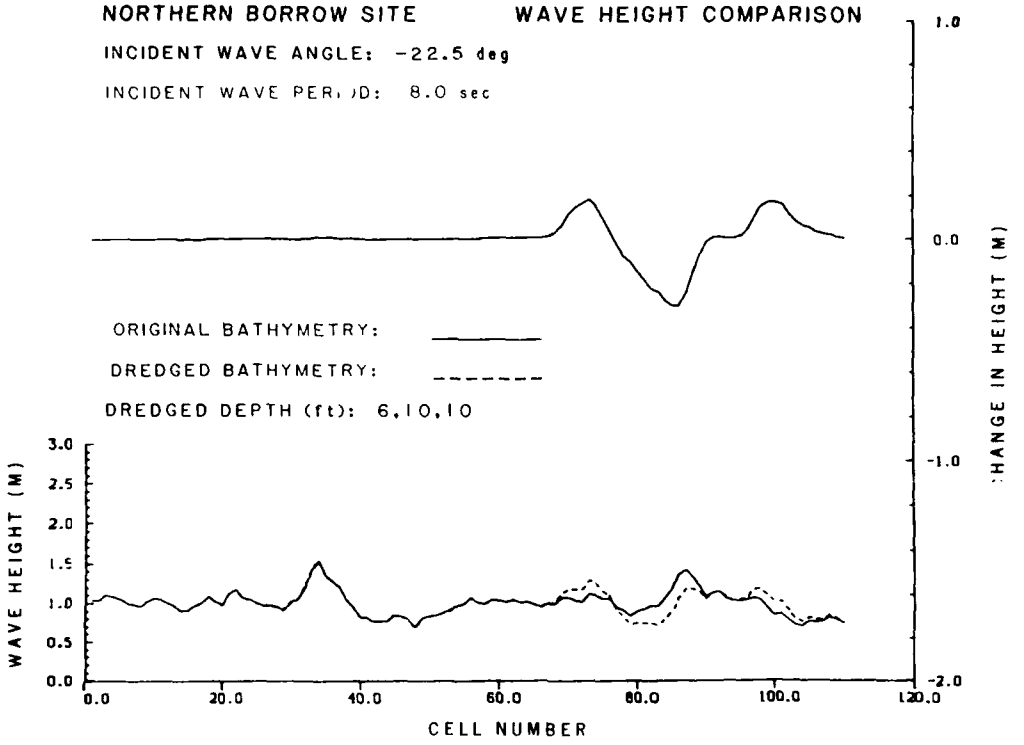

NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER

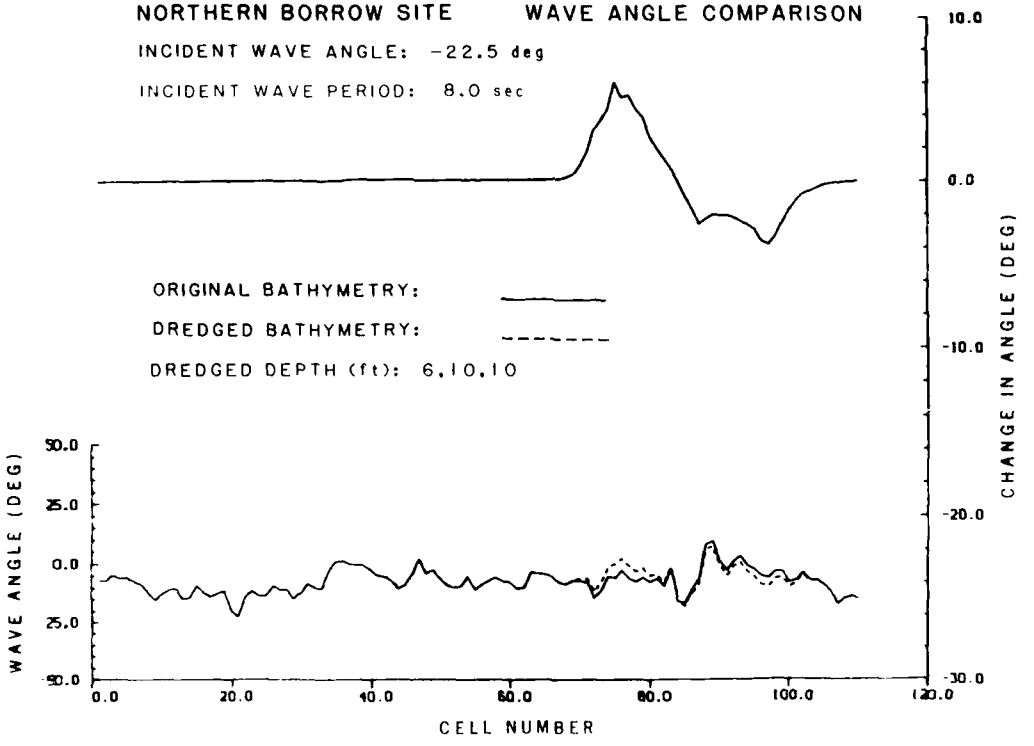

NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,20
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER

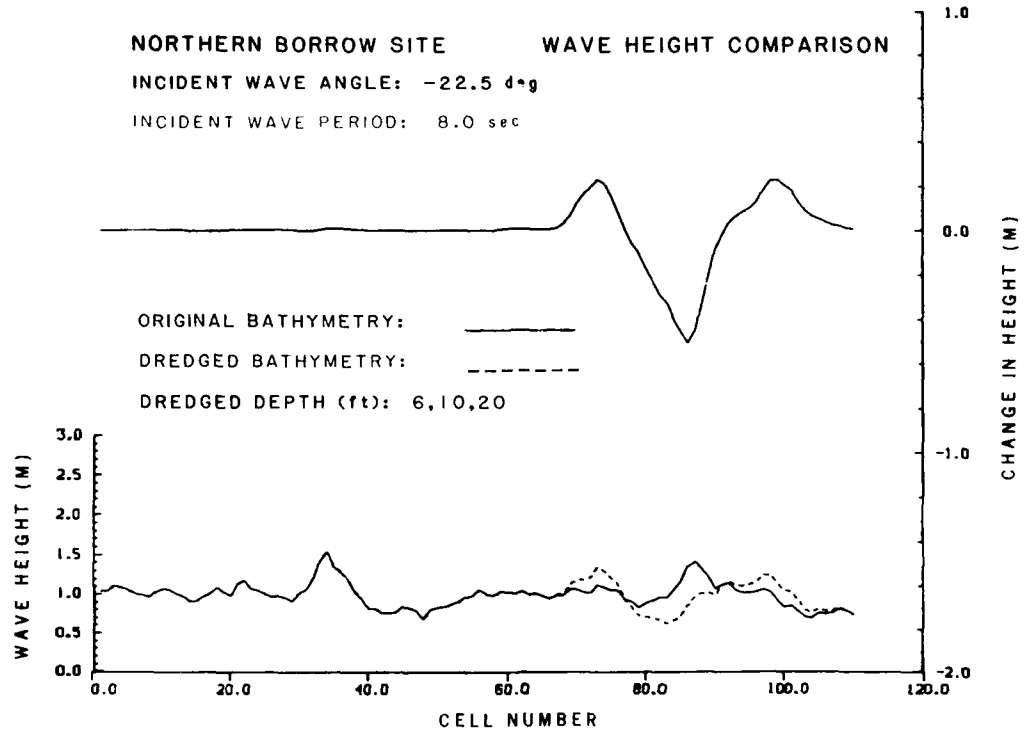

NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,20
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER

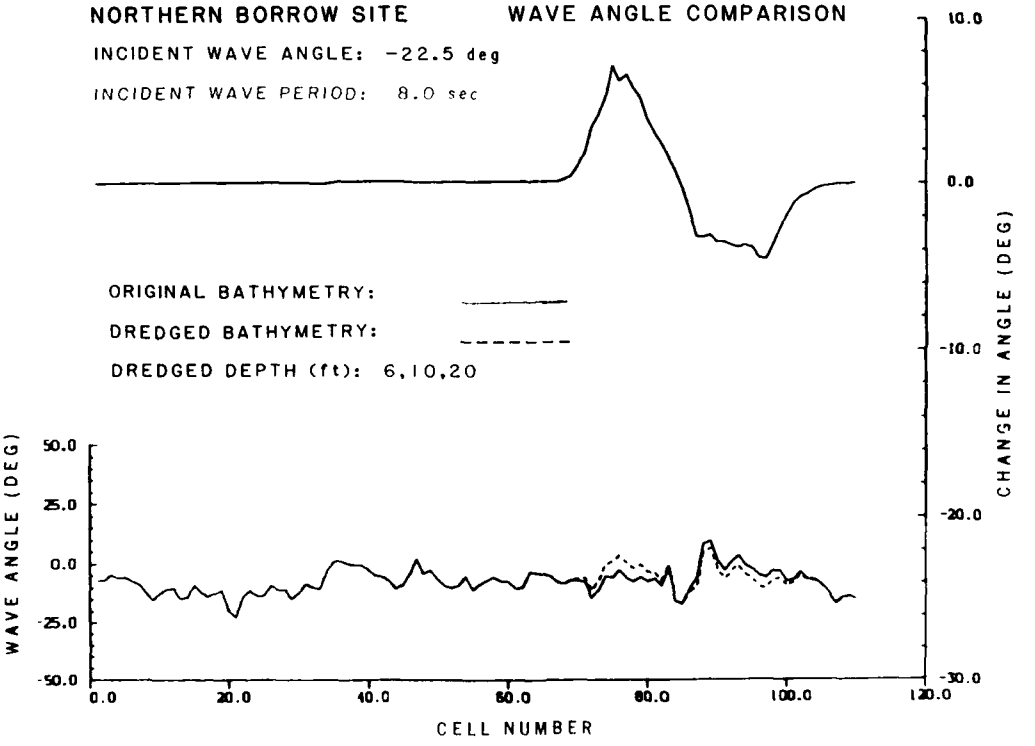

NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER

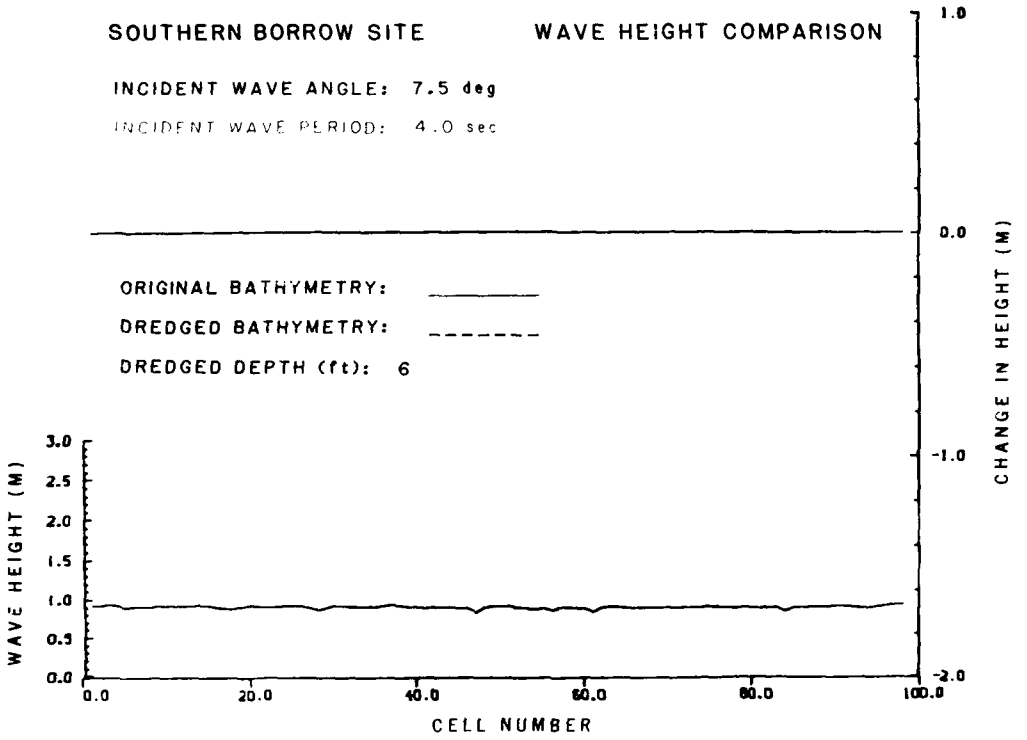

NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,6,6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER

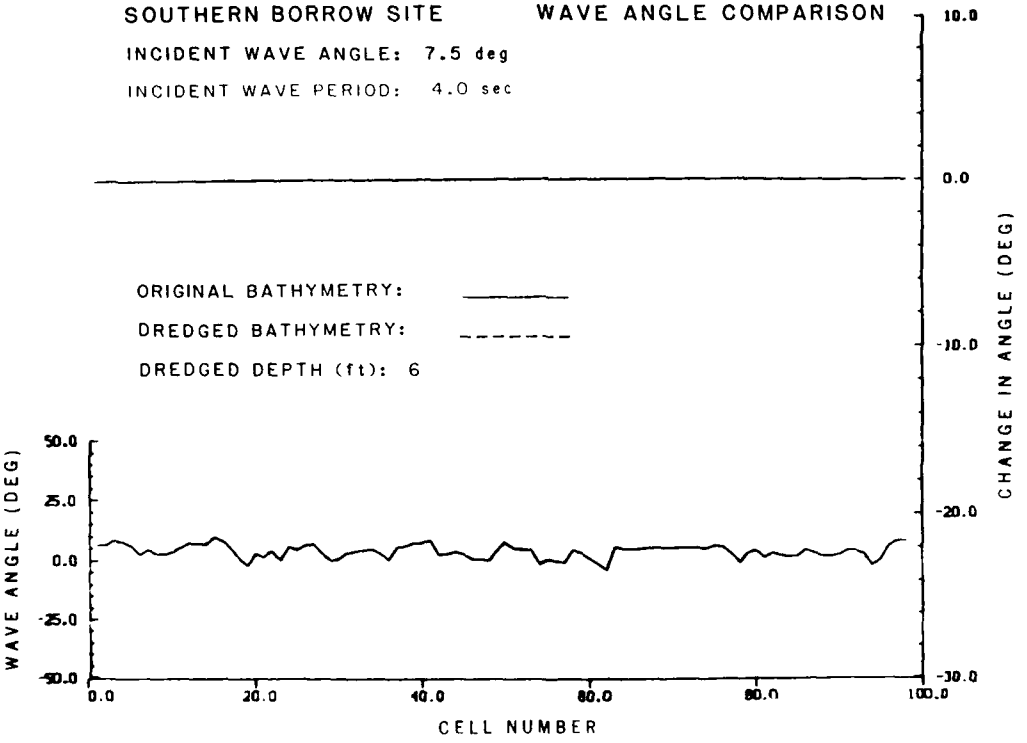

NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0

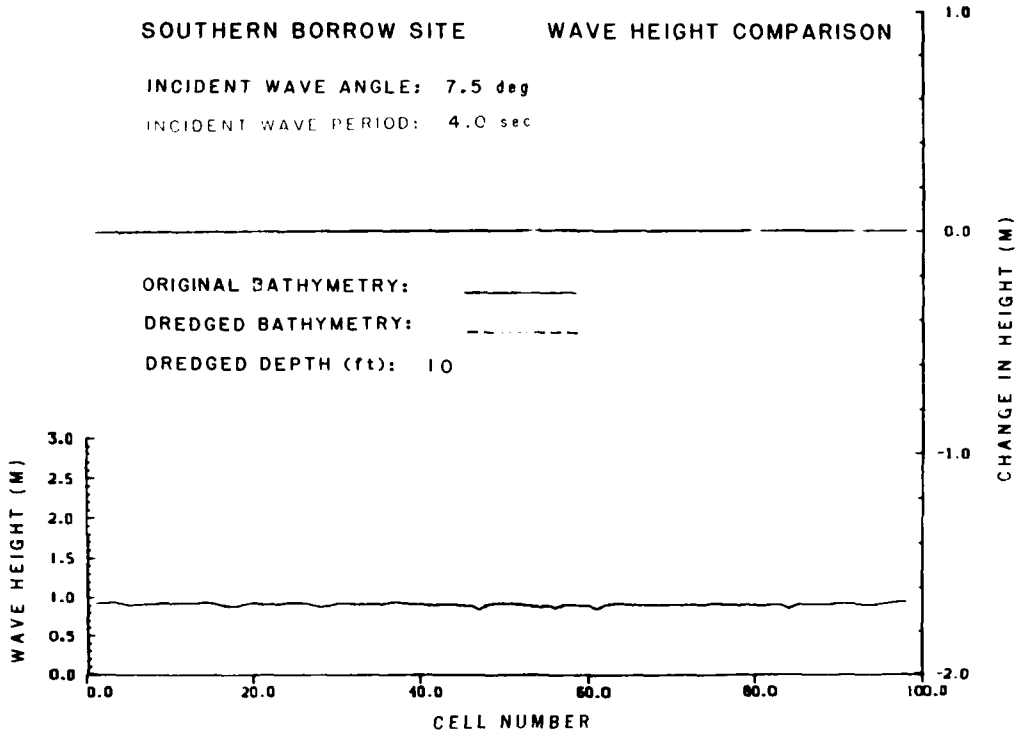

NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0


NORTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,20
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0


NORTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6,10,20
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
0.0
20.0
40.0
60.0
80.0
100.0
120.0


SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER


SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER


SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
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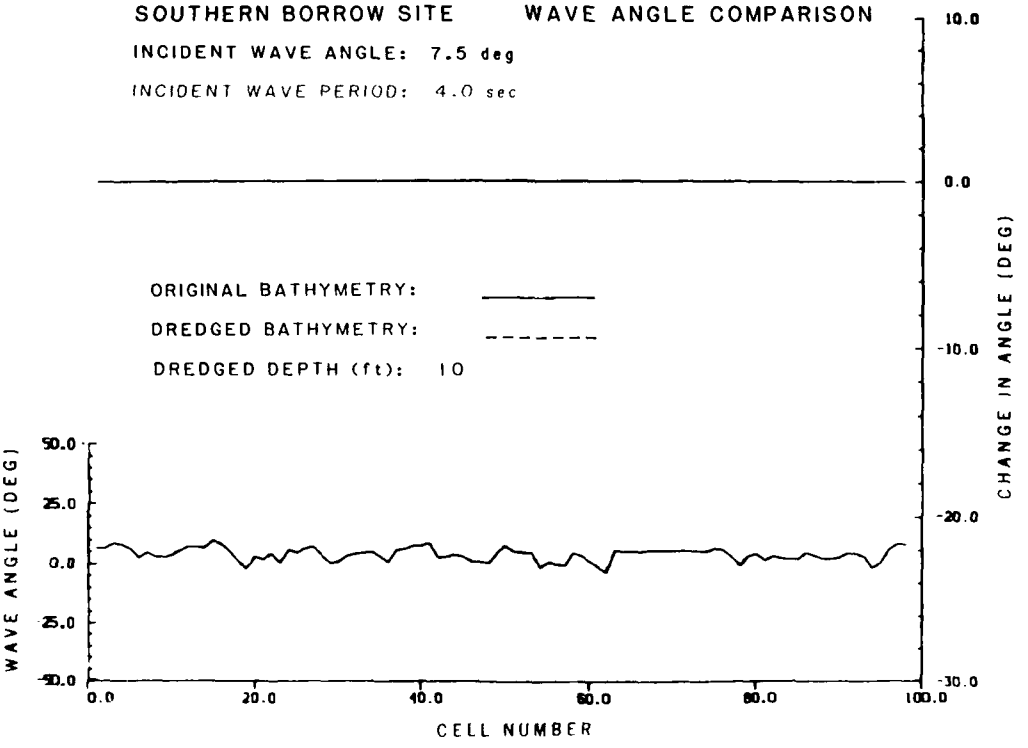
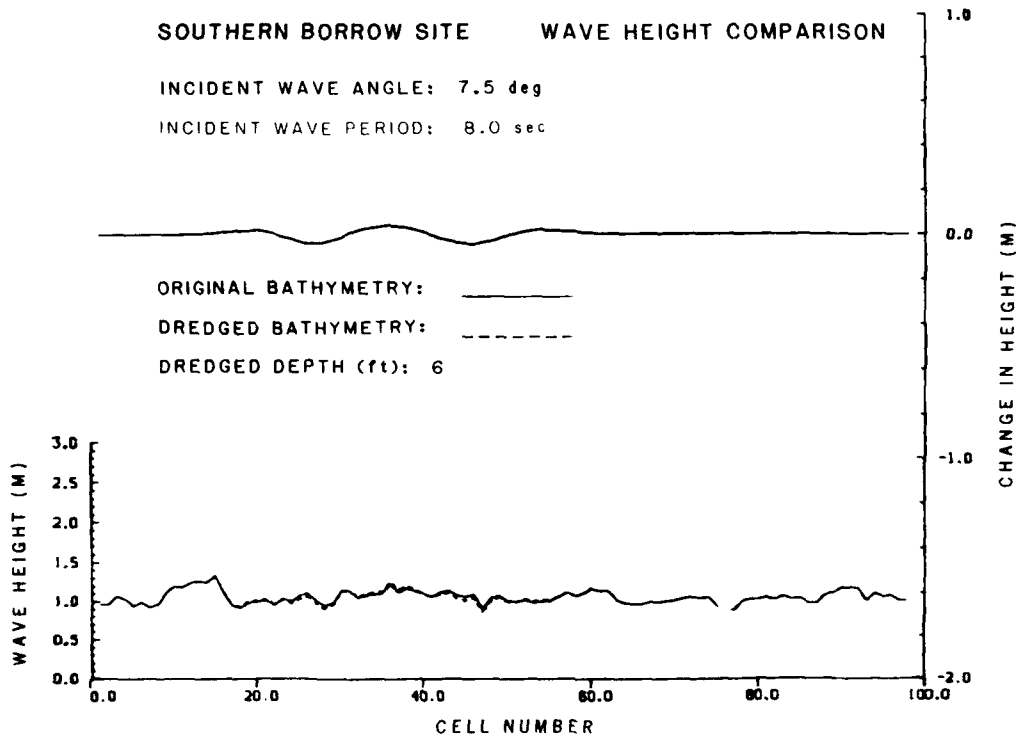
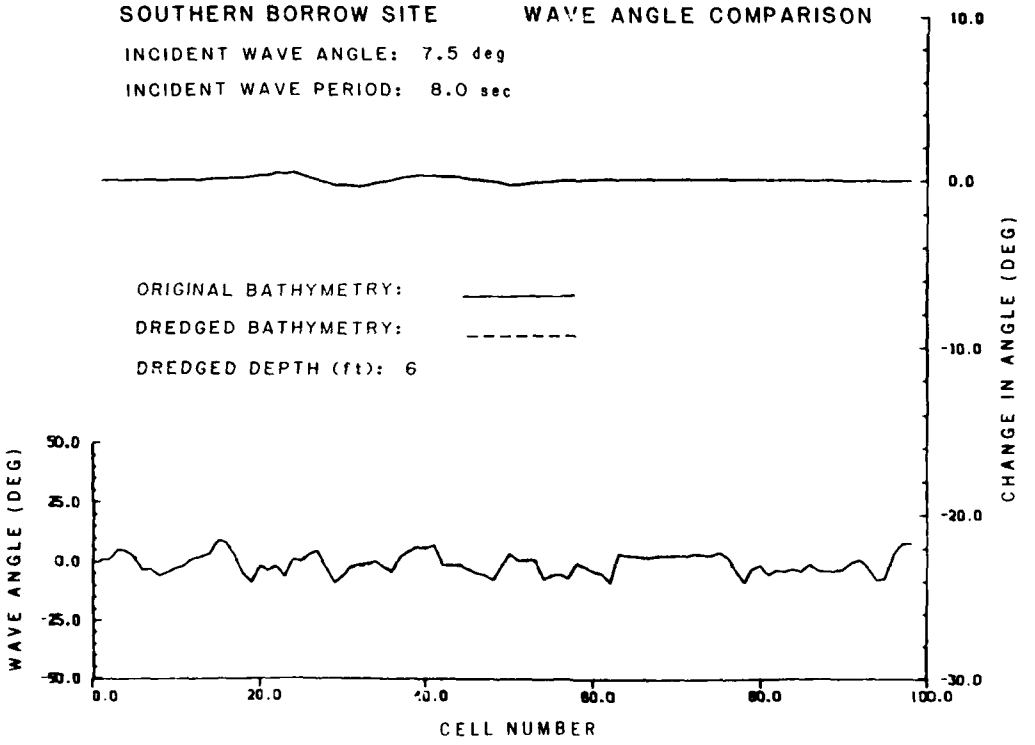
60.0
80.0
100.0


SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 4.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
0.0
20.0
40.0
60.0
80.0
100.0


SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
40.0
60.0
80.0
100.0


SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
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20.0
40.0
60.0
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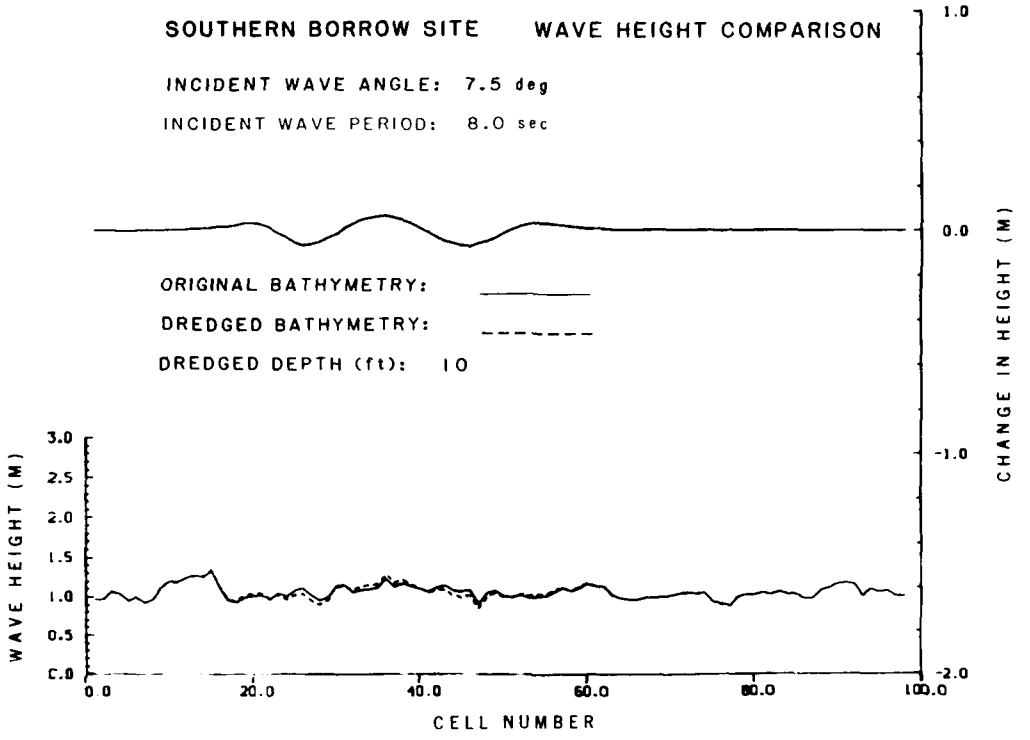
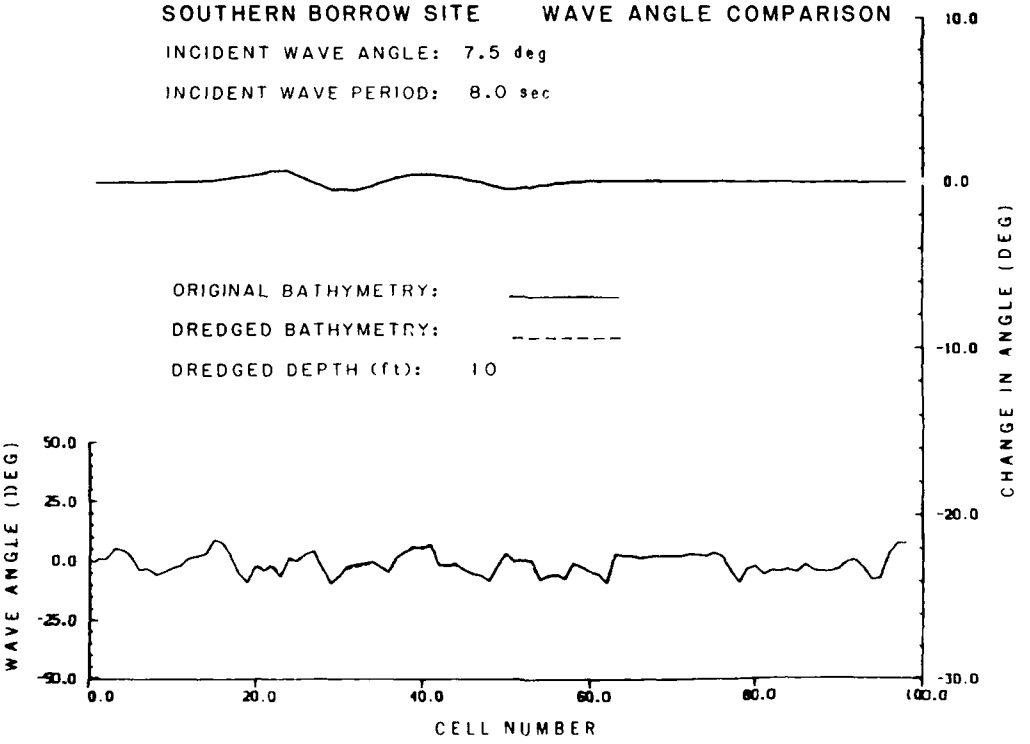
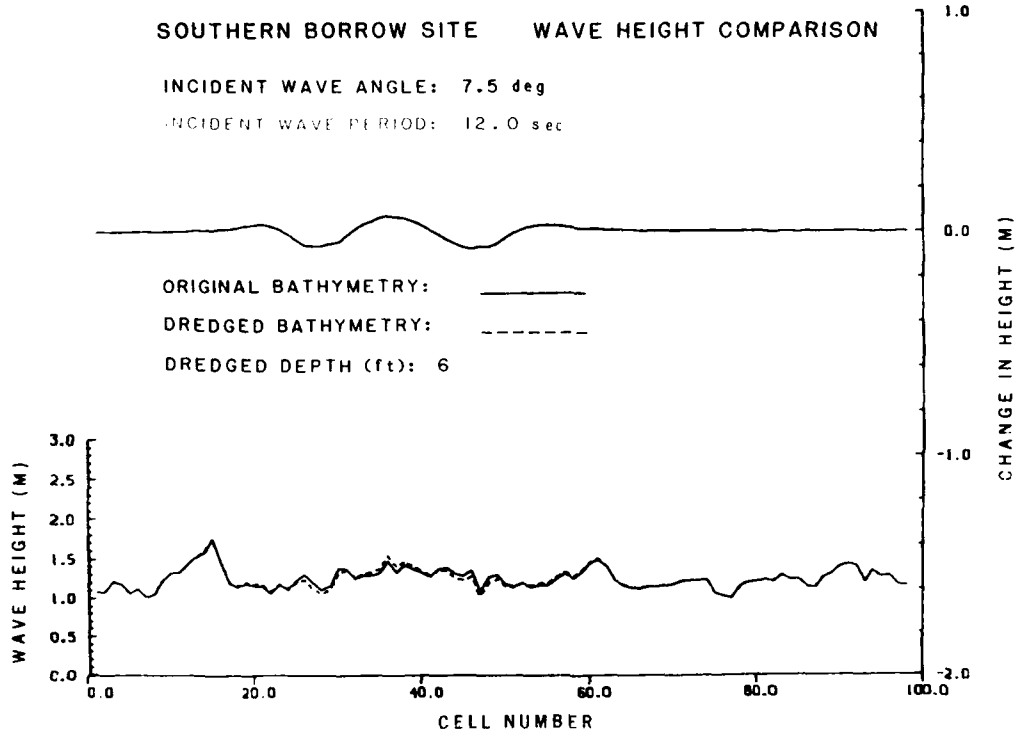
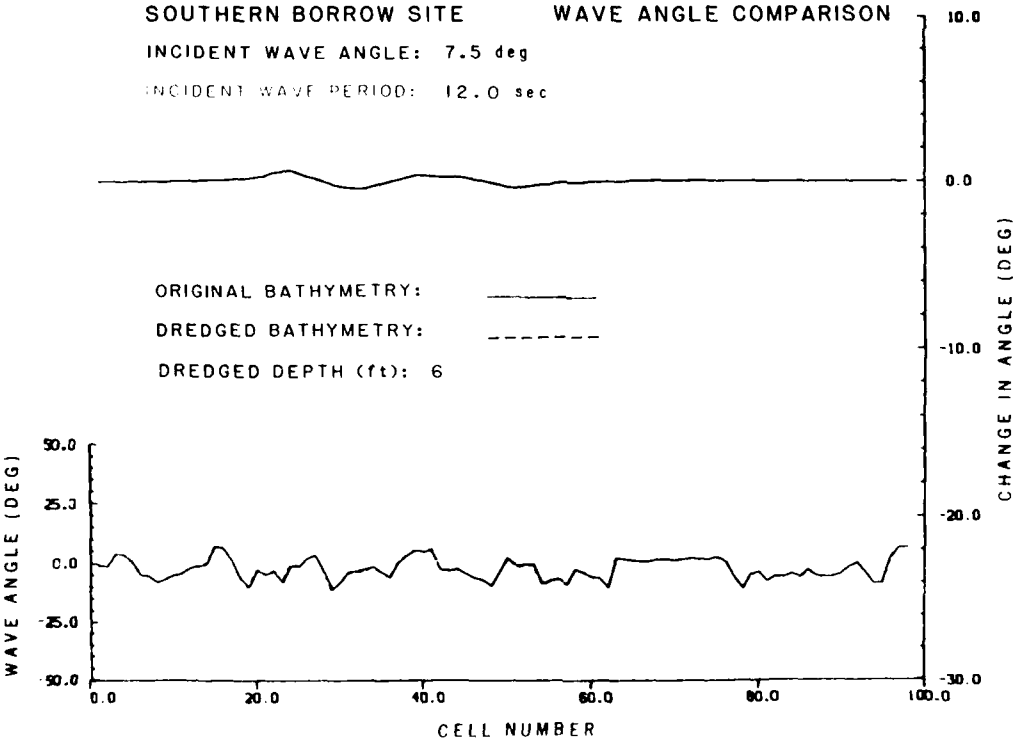
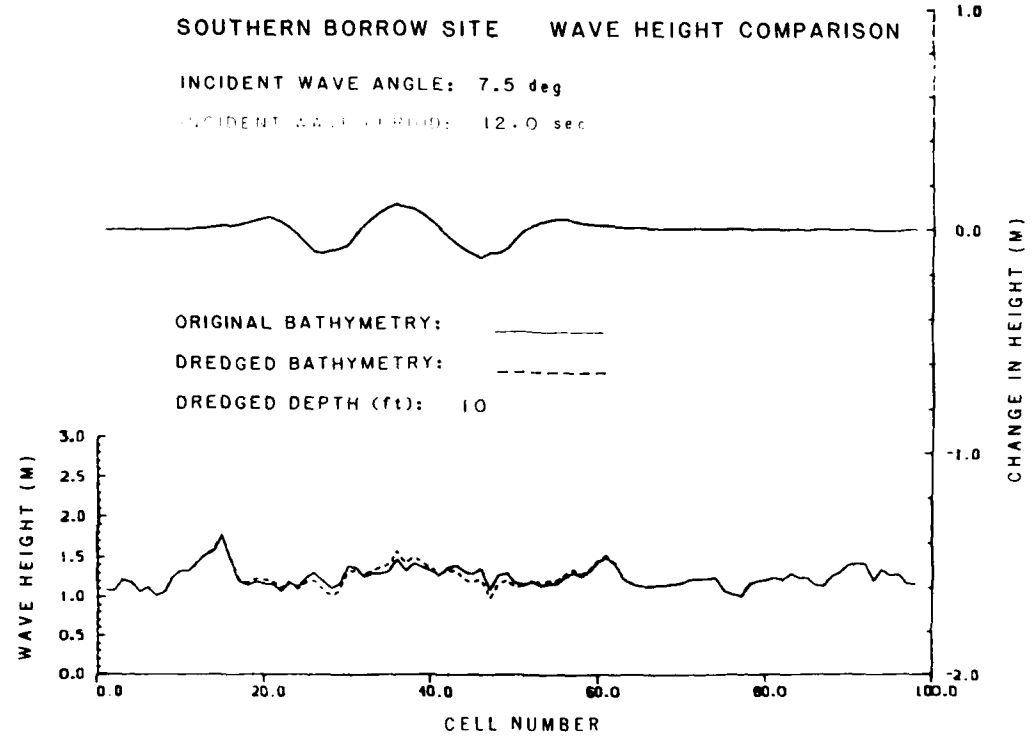

SOUTHERN BORROW SITE WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER


SOUTHERN BORROW SITE WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER


SOUTHERN BORROW SITE WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 12.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER


SOUTHERN BORROW SITE WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 12.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER


SOUTHERN BORROW SITE WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 12.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
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60.0
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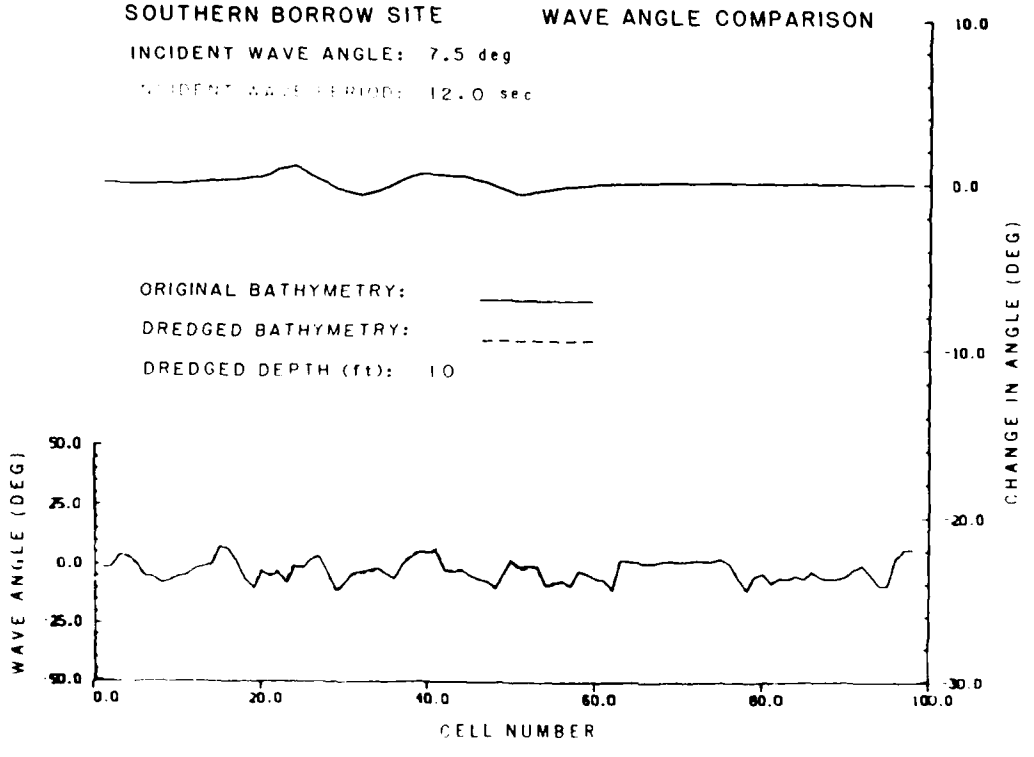
100.0


SOUTHERN BORROW SITE WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 7.5 deg
INCIDENT WAVE PERIOD: 12.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
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-10.0
-20.0
-30.0
0.0
20.0
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60.0
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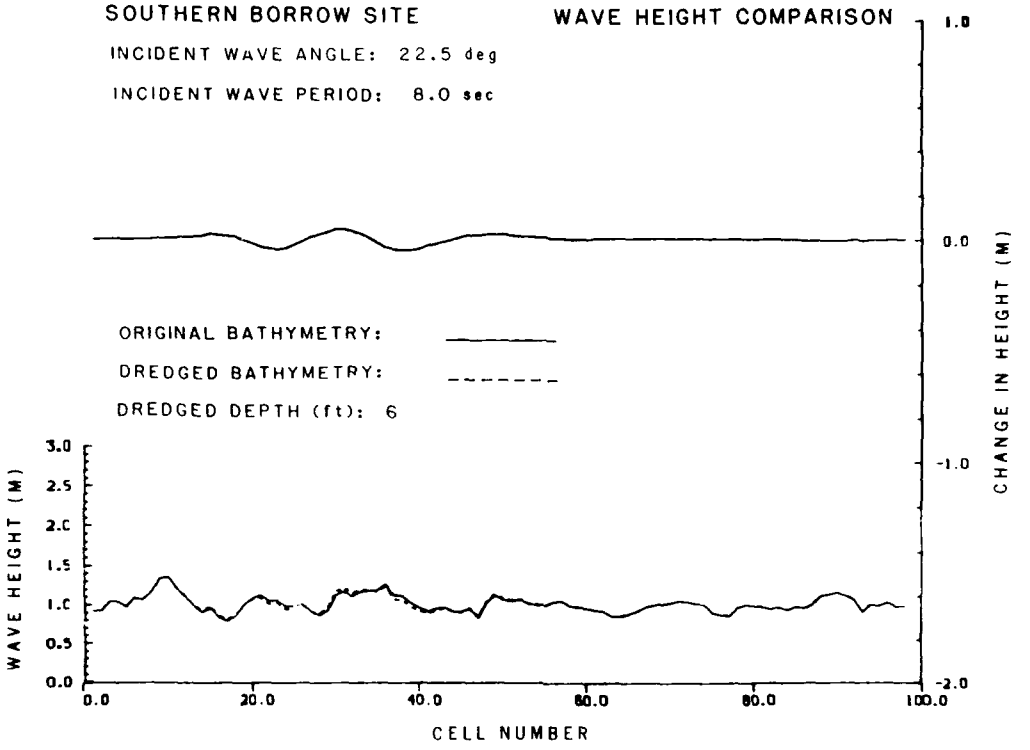
100.0


SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
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1.0
0.0
-1.0
-2.0
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20.0
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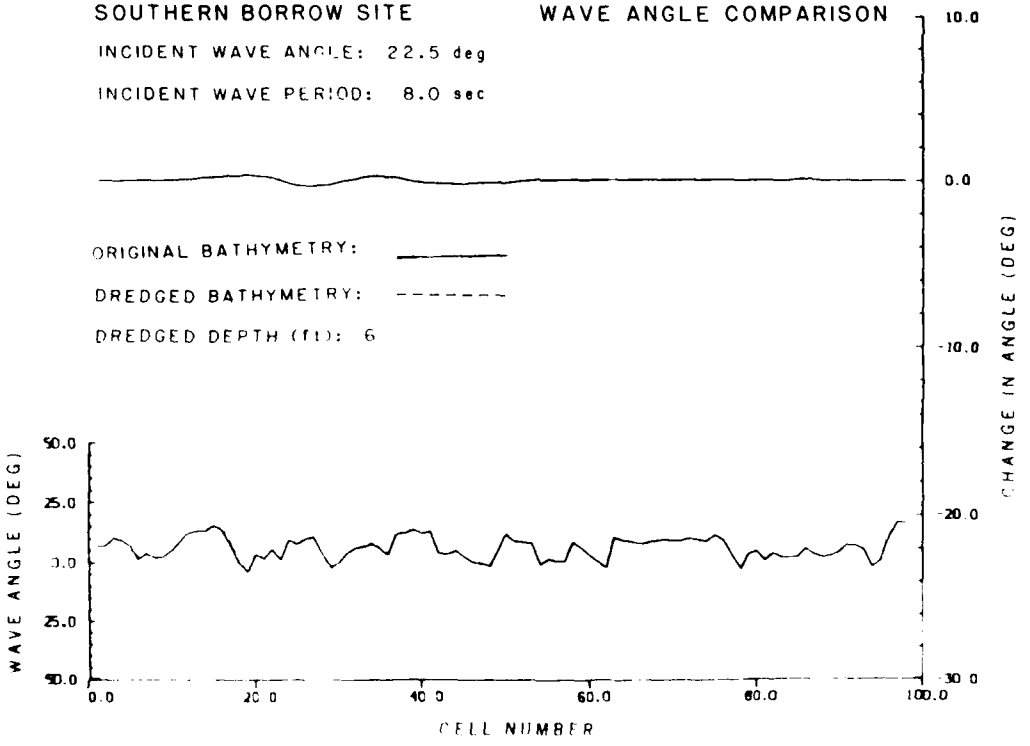
100.0


SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
25.0
50.0
10.0
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-10.0
-20.0
-30.0
0.0
20.0
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60.0
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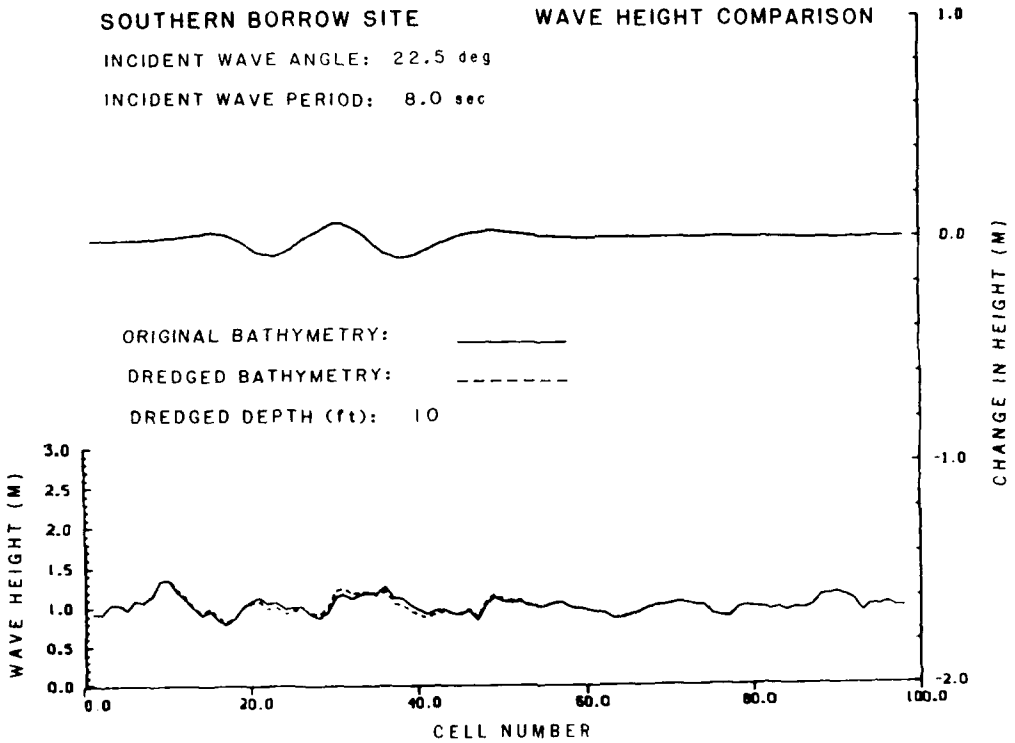
100.0


SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
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-2.0
0.0
20.0
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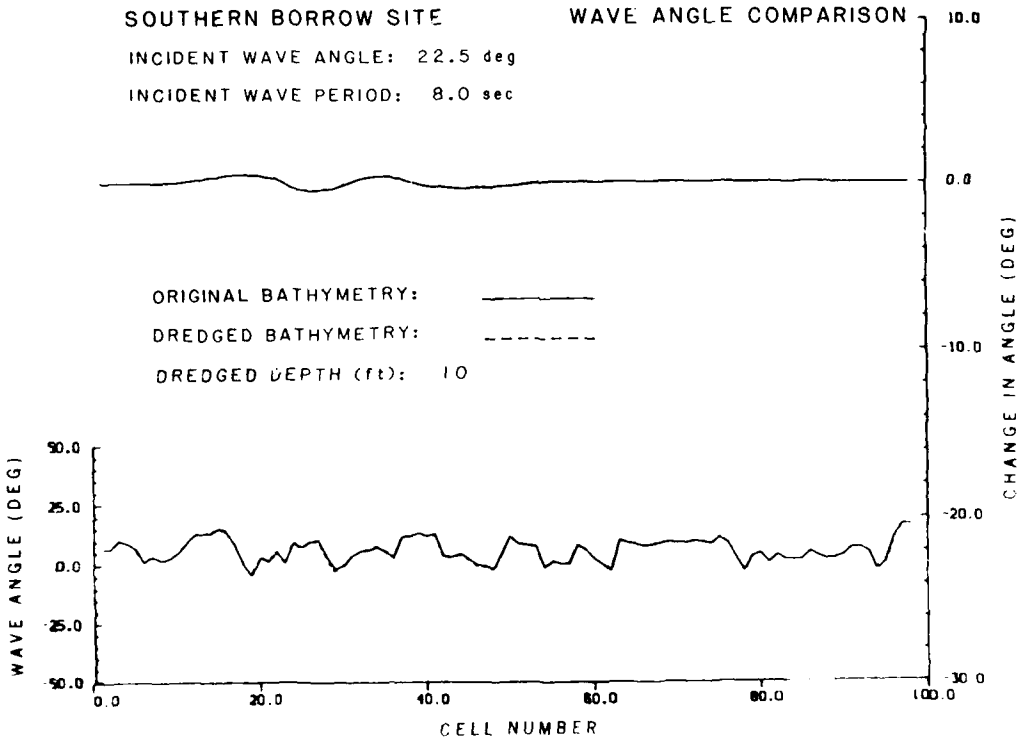
SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: 22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
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-10.0
-20.0
-30.0
0.0
20.0
40.0
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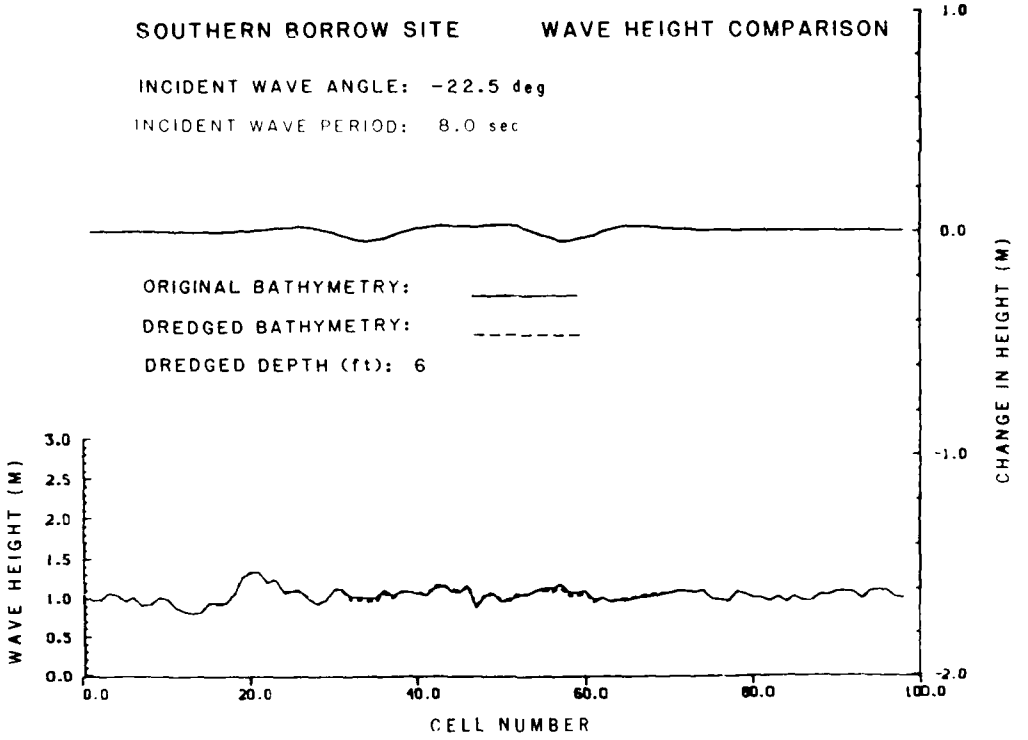
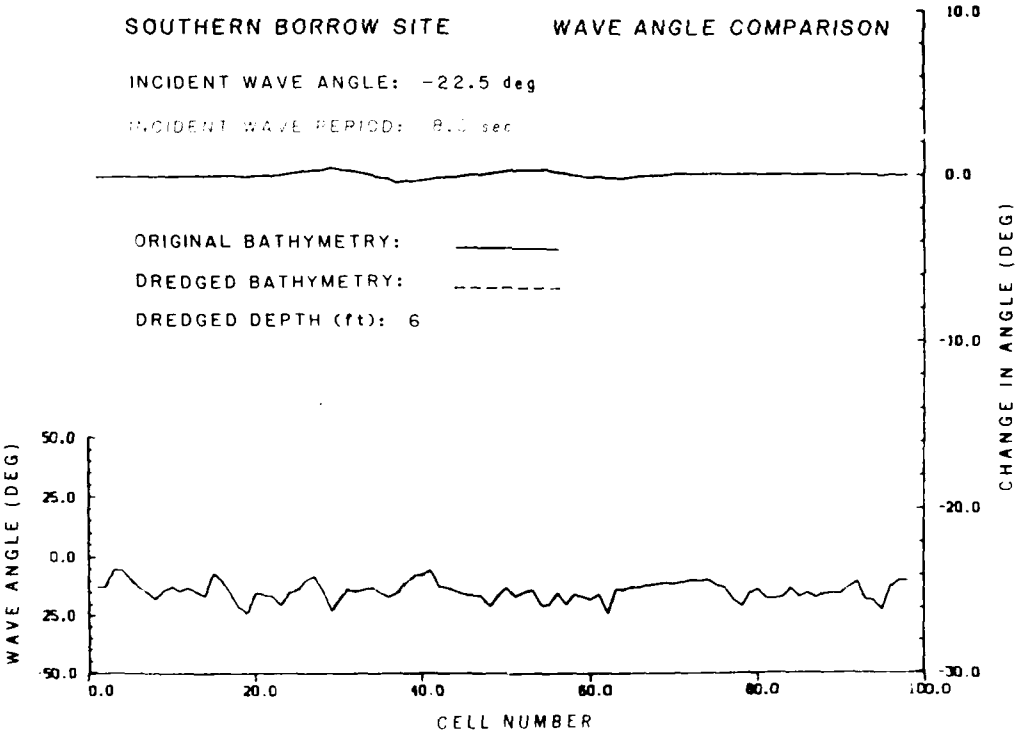
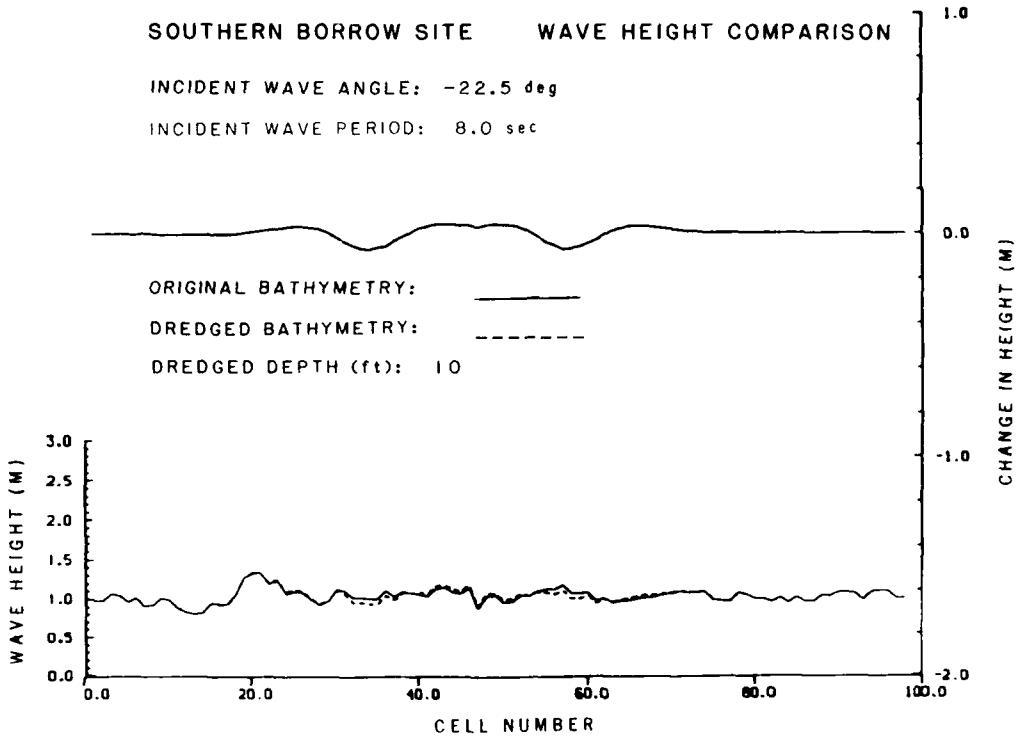
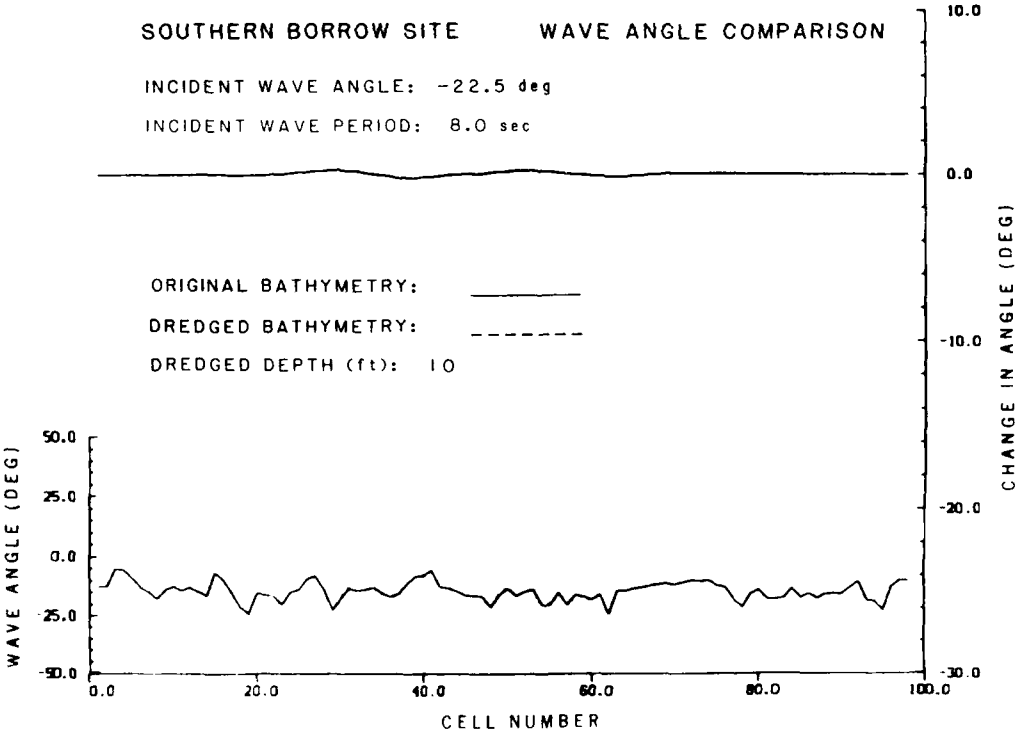

SOUTHERN BORROW SITE
WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
40.0
60.0
80.0
100.0


SOUTHERN BORROW SITE
WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 6
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
0.0
20.0
40.0
60.0
80.0
100.0


SOUTHERN BORROW SITE WAVE HEIGHT COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE HEIGHT (M)
CHANGE IN HEIGHT (M)
CELL NUMBER
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.0
-1.0
-2.0
0.0
20.0
40.0
60.0
80.0
100.0

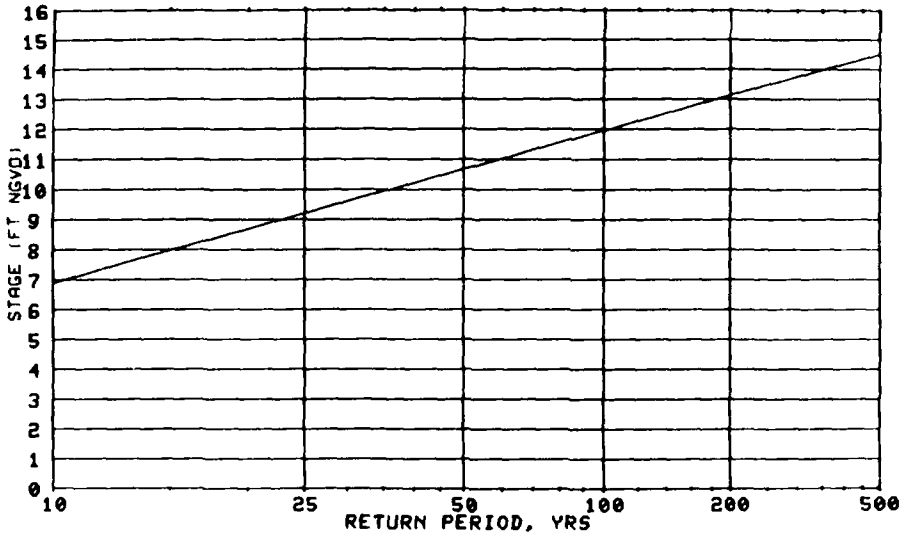

SOUTHERN BORROW SITE WAVE ANGLE COMPARISON
INCIDENT WAVE ANGLE: -22.5 deg
INCIDENT WAVE PERIOD: 8.0 sec
ORIGINAL BATHYMETRY:
DREDGED BATHYMETRY:
DREDGED DEPTH (ft): 10
WAVE ANGLE (DEG)
CHANGE IN ANGLE (DEG)
CELL NUMBER
50.0
25.0
0.0
-25.0
-50.0
10.0
0.0
-10.0
-20.0
-30.0
0.0
20.0
40.0
60.0
80.0
100.0

APPENDIX G: BACK-BAY STAGE-FREQUENCY CURVES

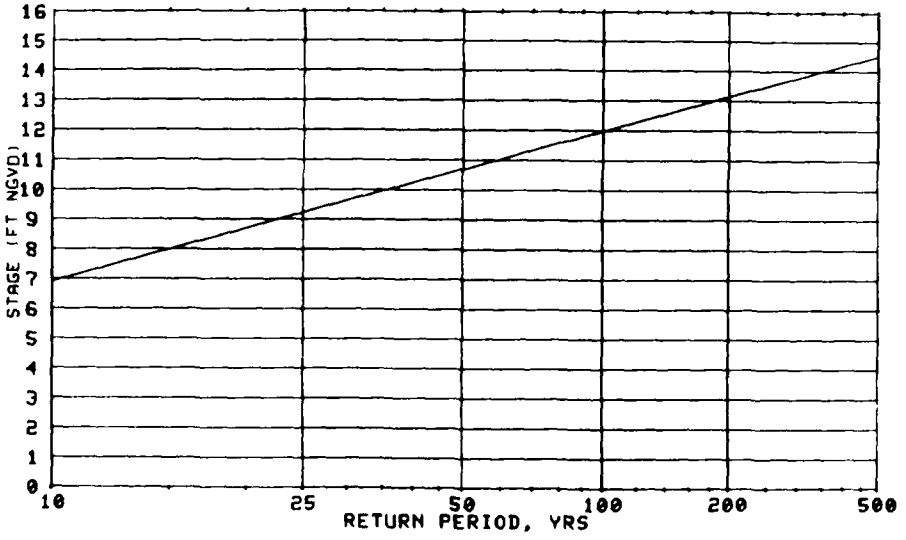
1. This appendix contains separate and combined hurricane and northeaster stage-frequency curves for the 20 numerical gages. As noted in Part VI, the raw stage-frequency curves were smoothed using linear regression. Also, the abscissa of each graph is based on a Weibull distribution to transform the curves to straight lines. The Weibull distribution is described by the equation:

$$x = (-\log x')^c \qquad \text{(G1)}$$

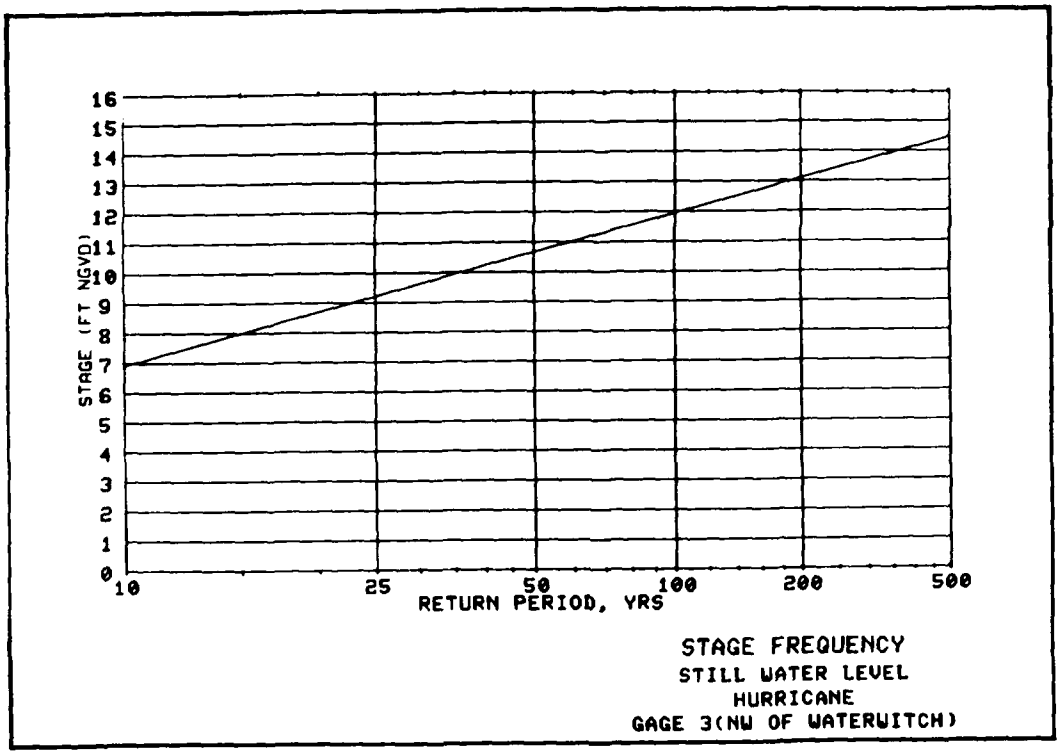
where x' is frequency, x is transformed abscissa value, and the exponent c is a variable to be adjusted to produce a straight line. It was found that the most suitable value for c is 0.3 for a hurricane and 0.8 for a northeaster. Most gages had a correlation coefficient greater than 0.98 for hurricanes and 0.96 for northeasters.



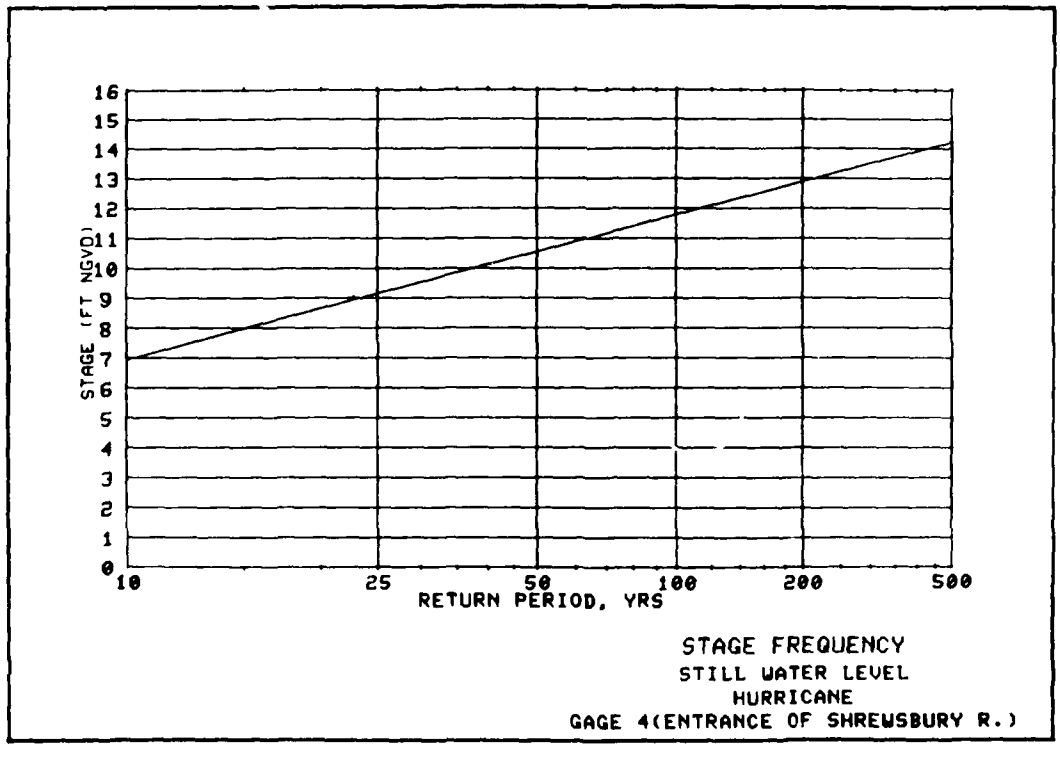
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 1(LEONARDO HARBOR)



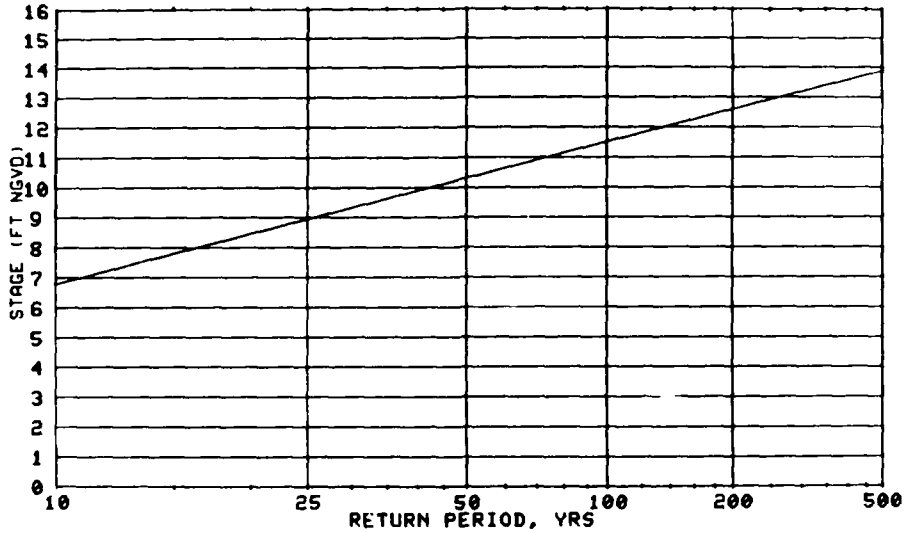
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 2(E. OF A. H. YACHT HARBOR)



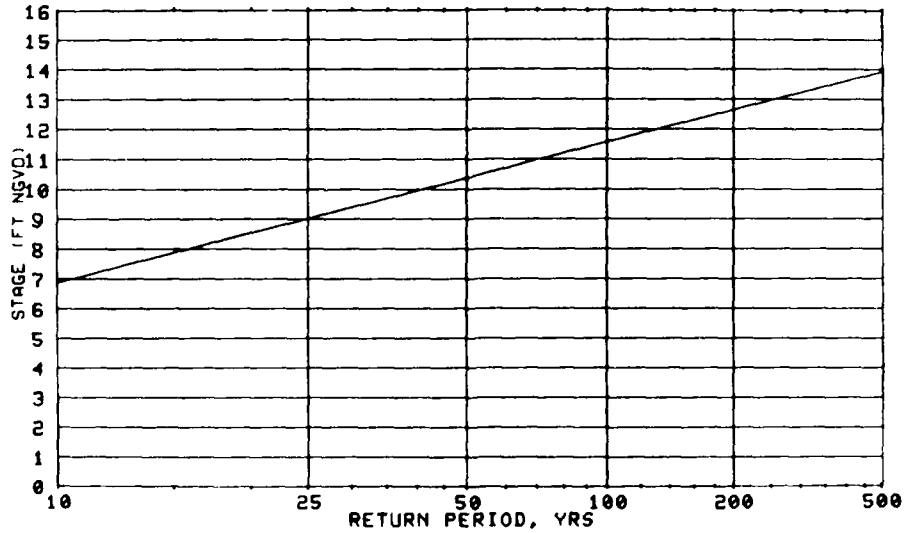
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 3(NW OF WATERWITCH)



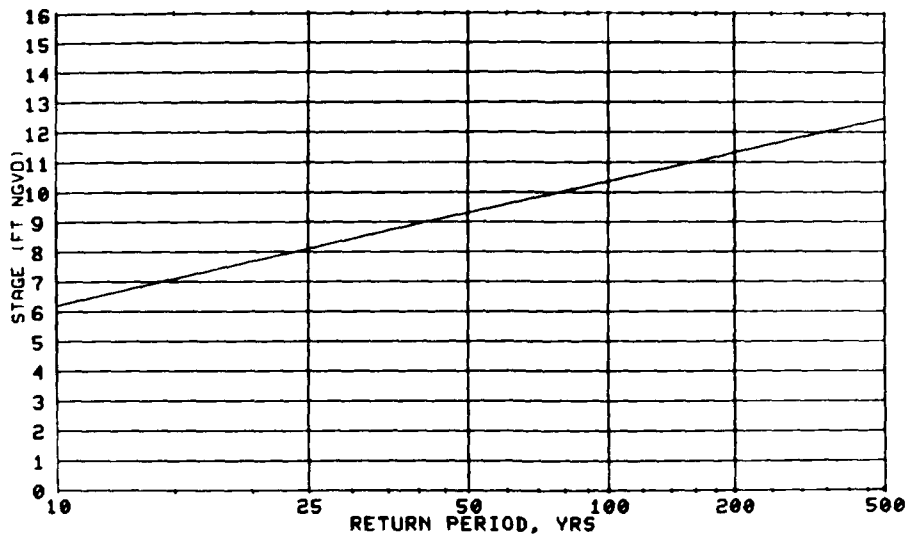
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 4(ENTRANCE OF SHREWSBURY R.)



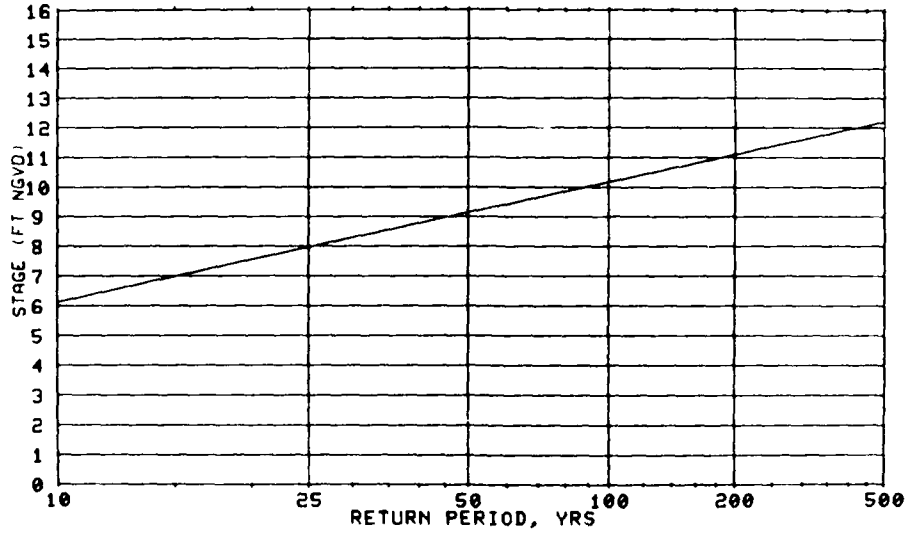
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 5(E END OF I-36 BRIDGE)



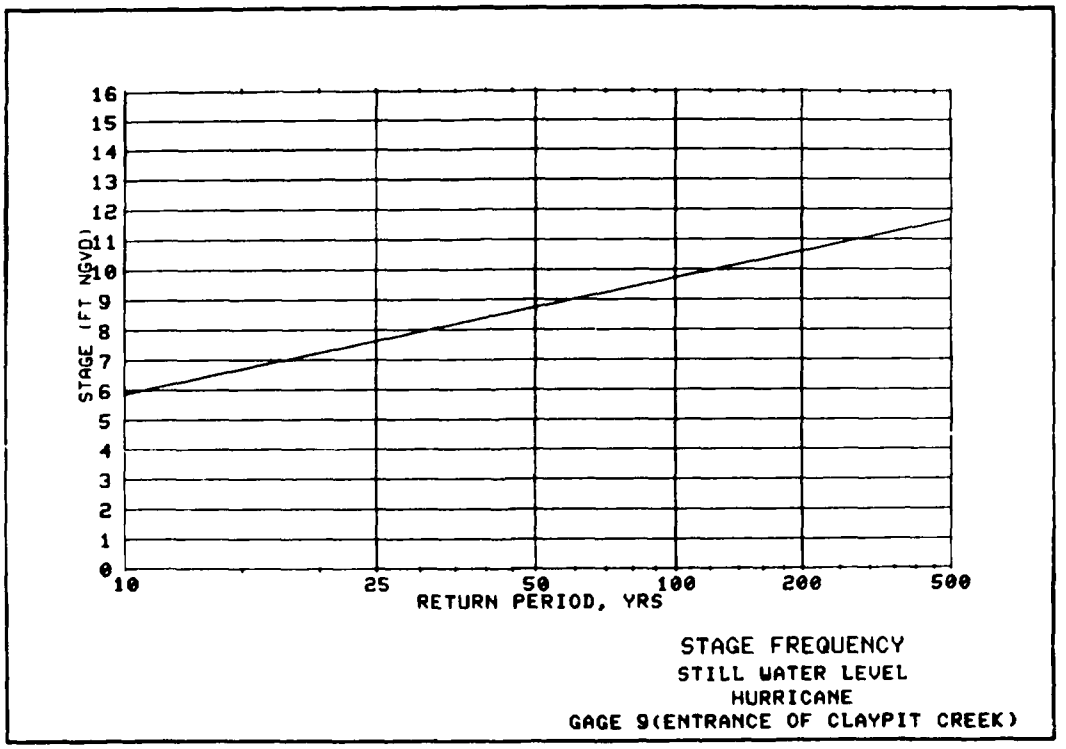
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 6(W END OF I-36 BRIDGE)



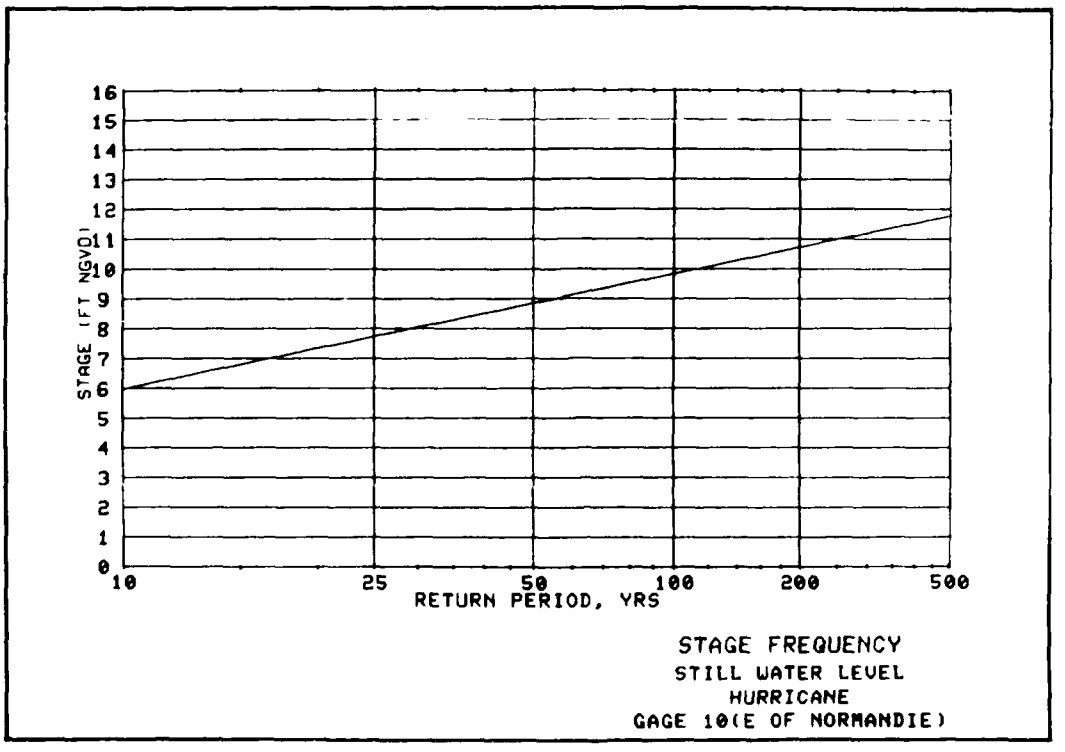
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 7(NAVESINK BEACH)



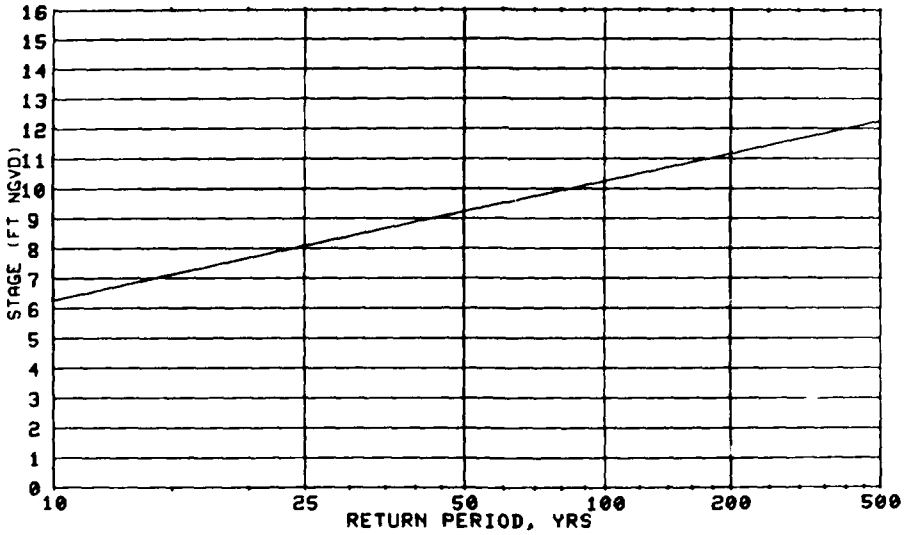
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 8(ENTRANCE OF NAVESINK R.)



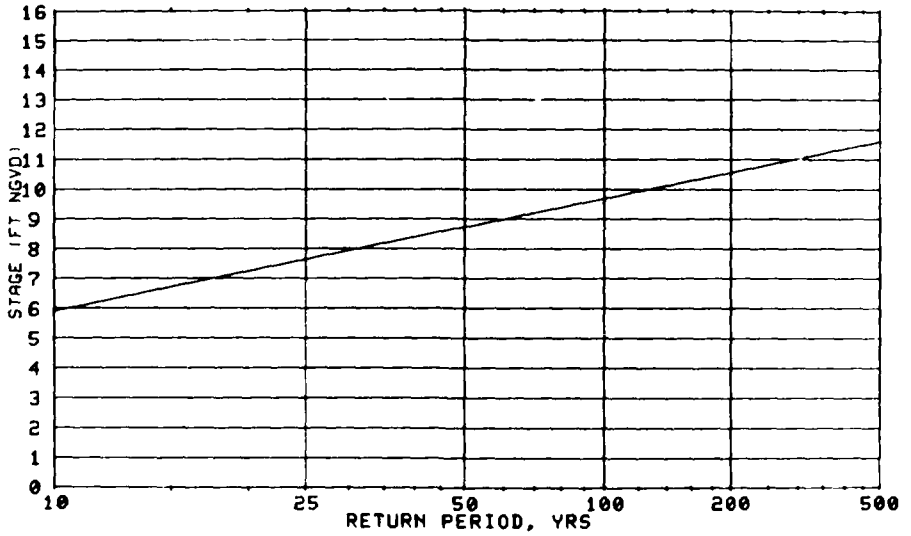
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 9(ENTRANCE OF CLAYPIT CREEK)



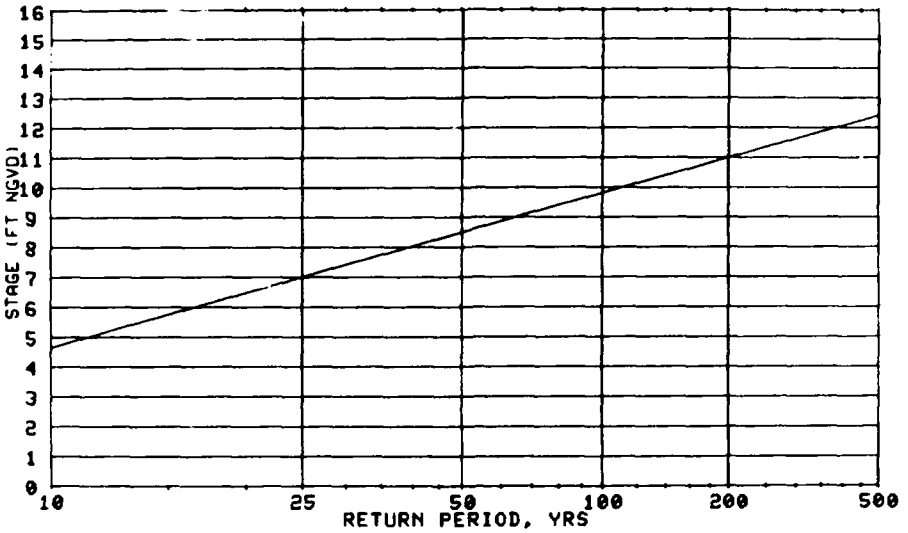
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 10(E OF NORMANDIE)



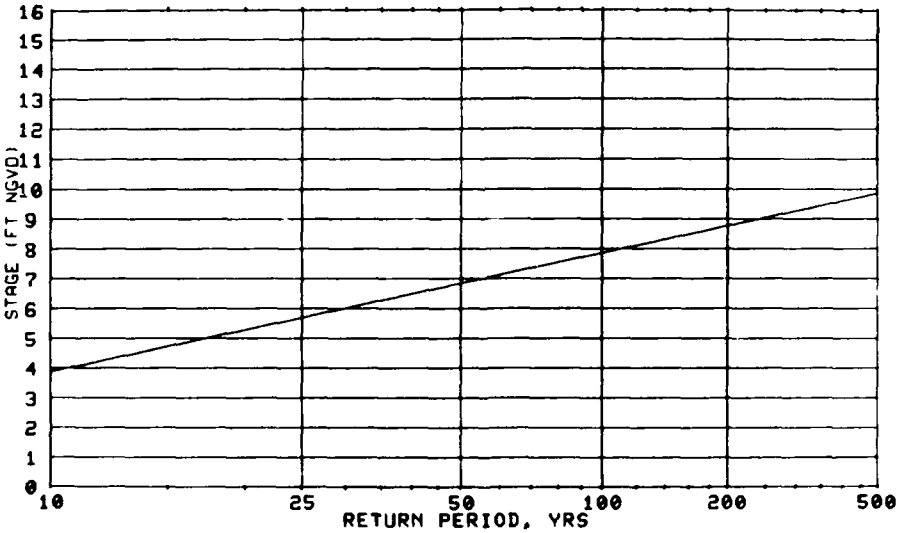
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 11(RUMRUNNER REST., SEA BRIGH



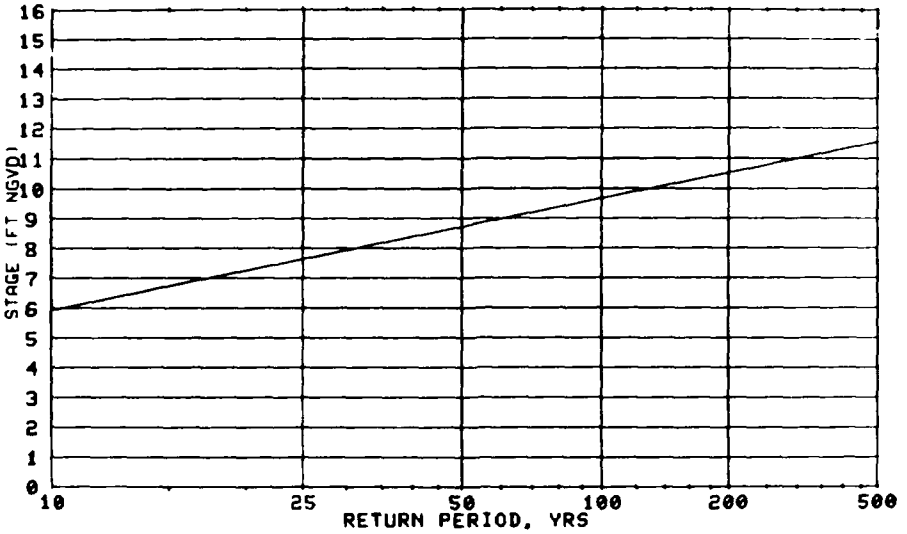
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 12(E FRONTAGE & EXT. OF HACEN



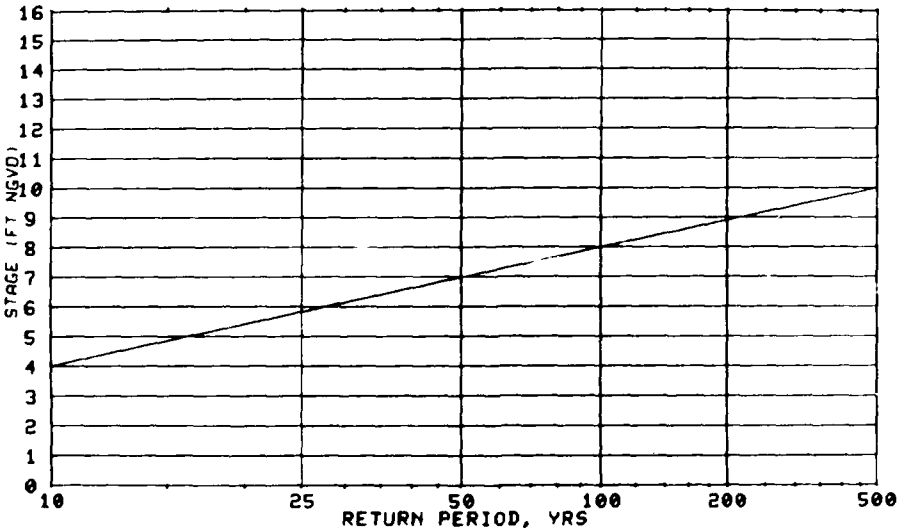
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 13(SEA BRIGHT)



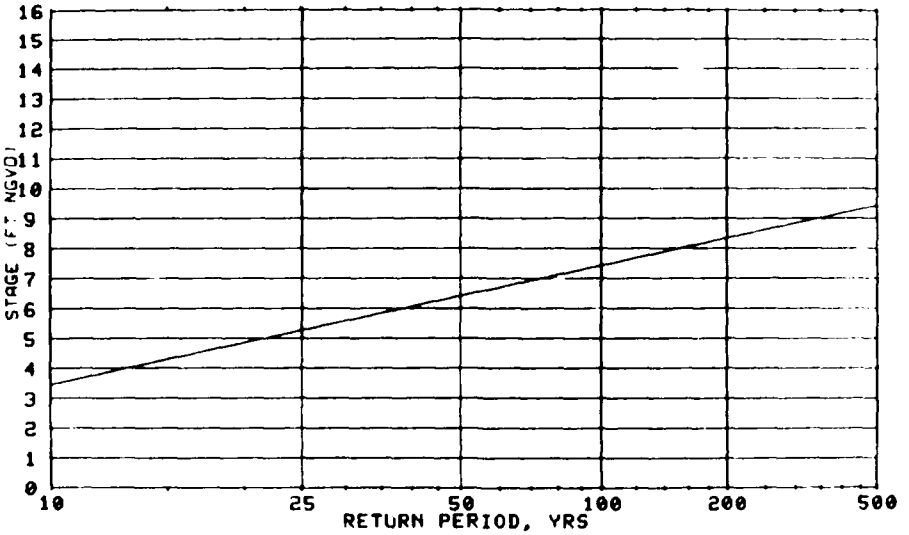
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 14(E OF THE ENTRANCE OF OYSTE



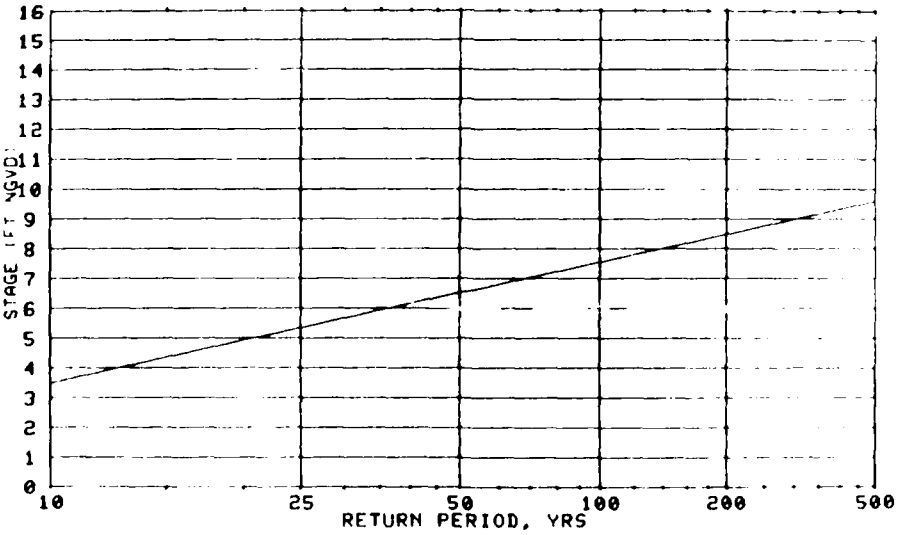
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 15(MAPLE AVE. & E. FRONTAGE)



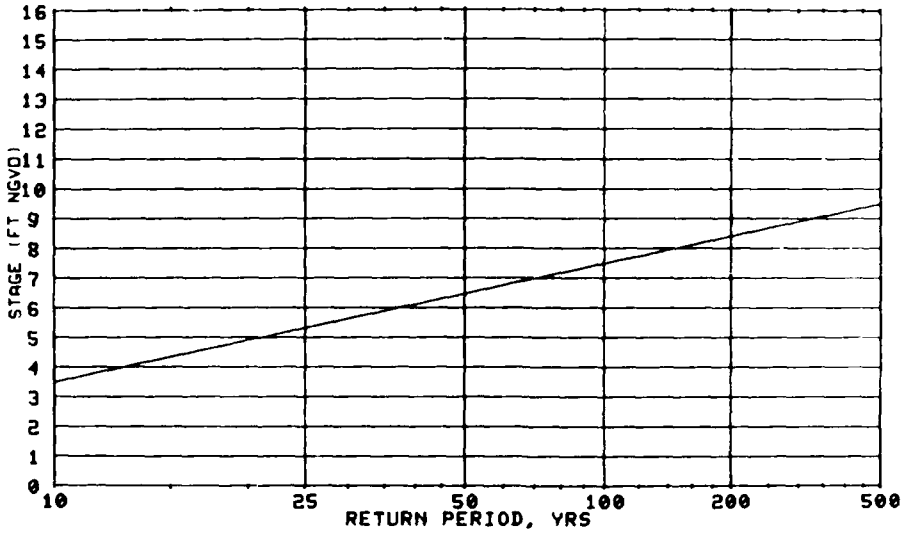
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 16(SHREWSBURY AT LOW MOOR)



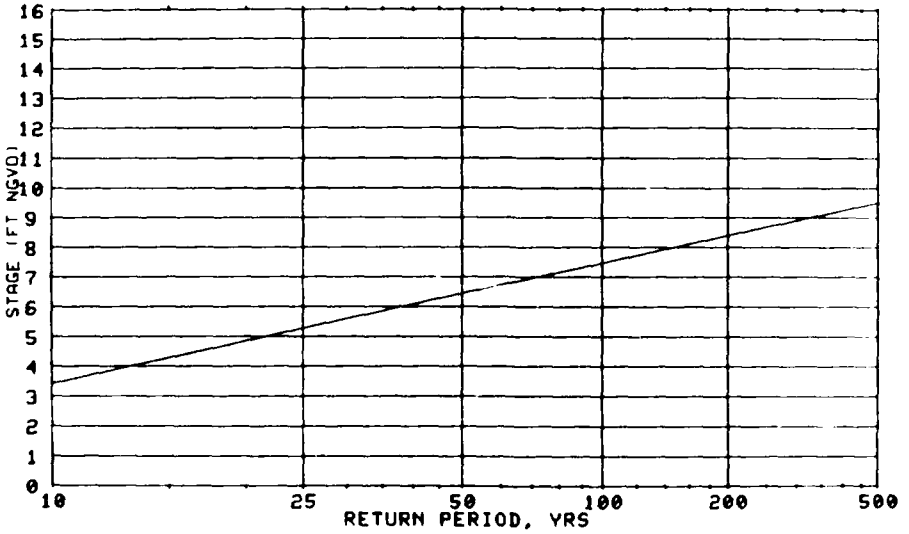
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 17(BTW. GALILEE & RACOON)



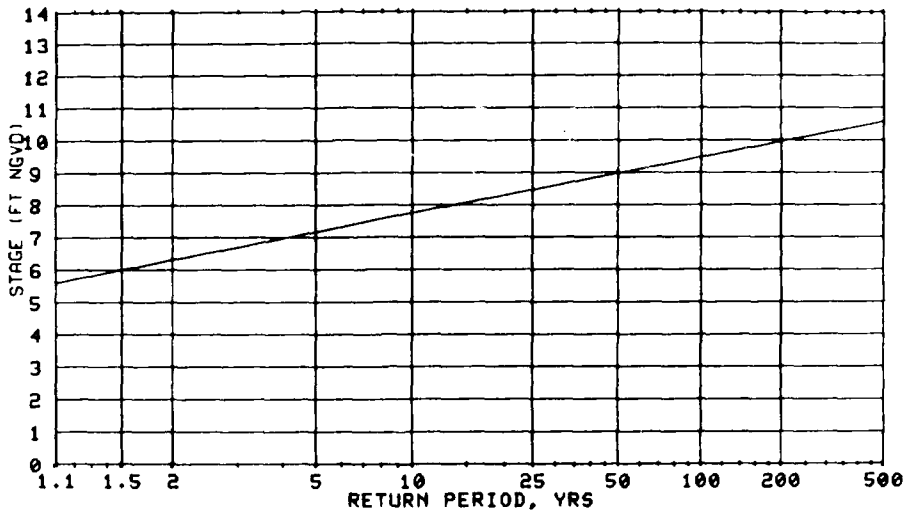
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 18(TIP OF SILVER PT. RD)



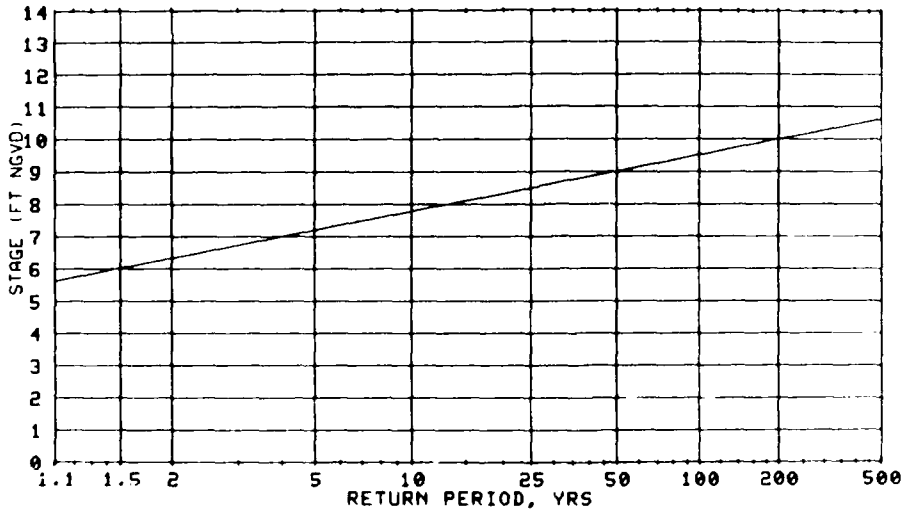
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 19(GALILEE)



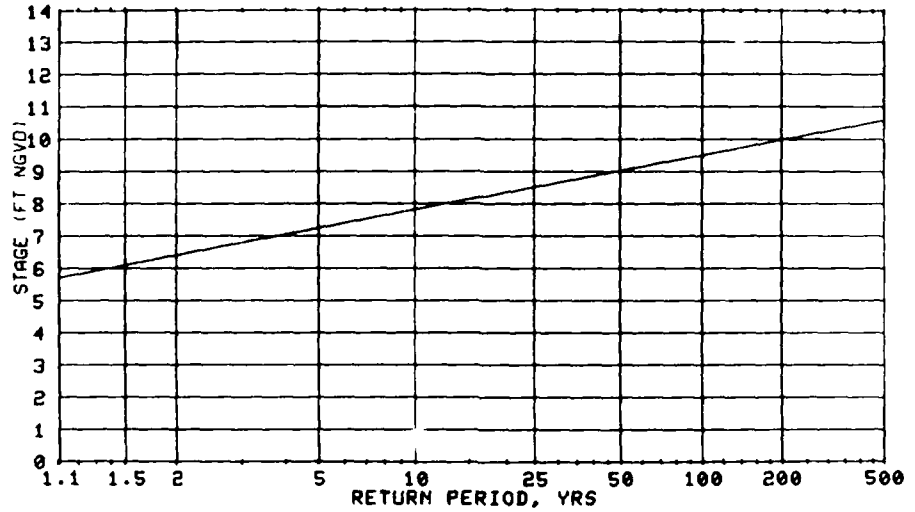
STAGE FREQUENCY
STILL WATER LEVEL
HURRICANE
GAGE 20(RACOON, PLEASURE BAY)



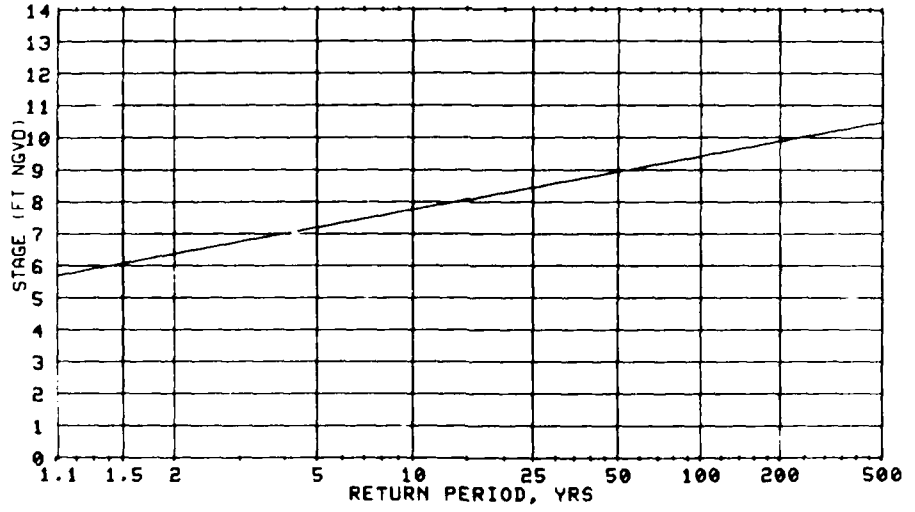
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 1(LEONARDO HARBOR)



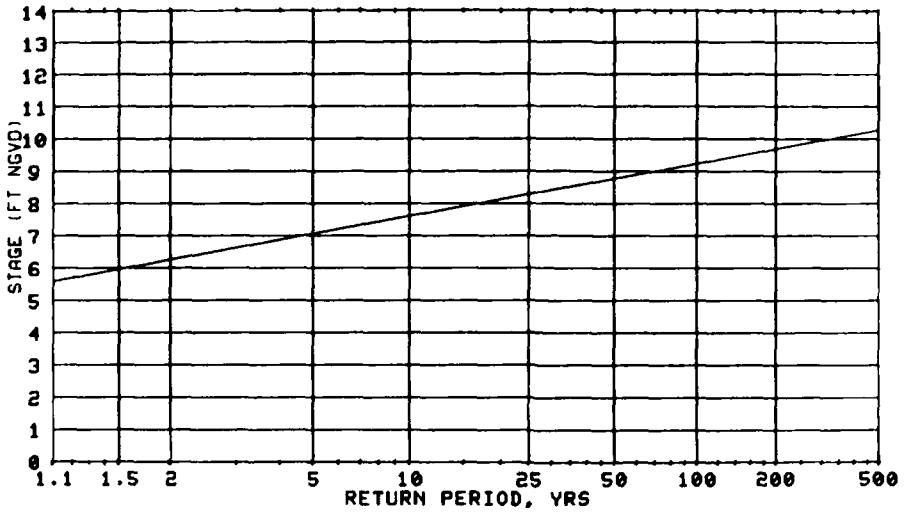
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 2(E. OF A. H. YACHT HARBOR)



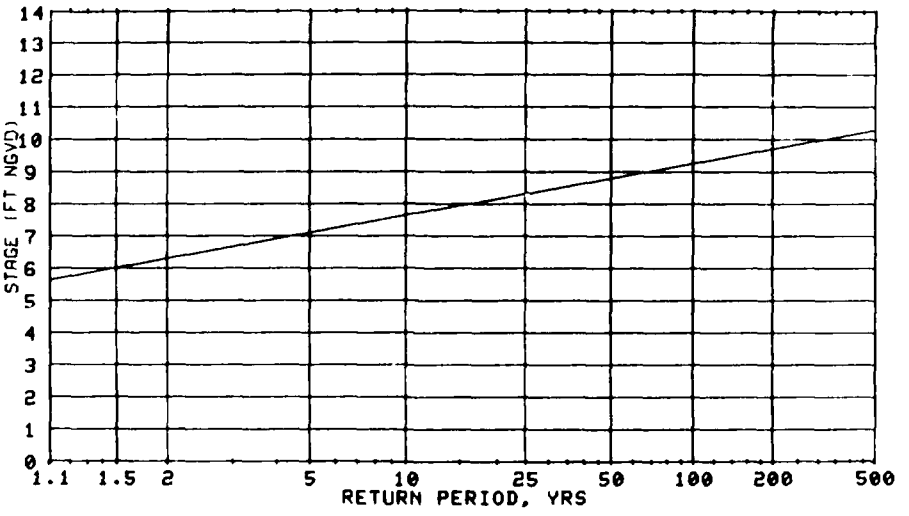
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 3(NW OF WATERWITCH)



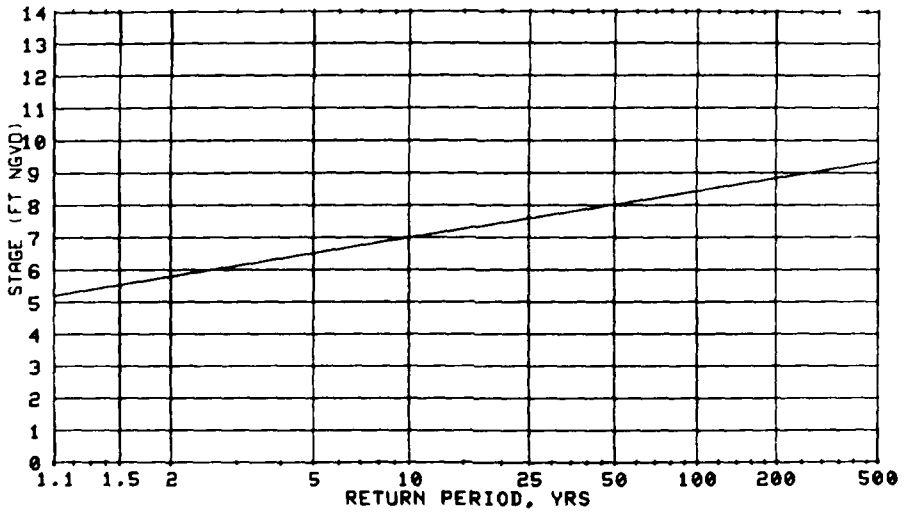
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 4(ENTRANCE OF SHREWSBURY R.)



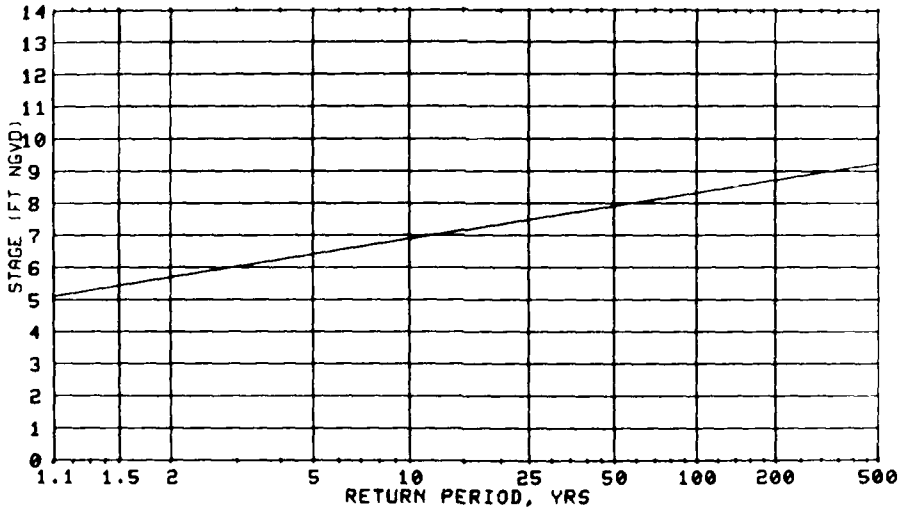
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 5(E END OF I-36 BRIDGE)



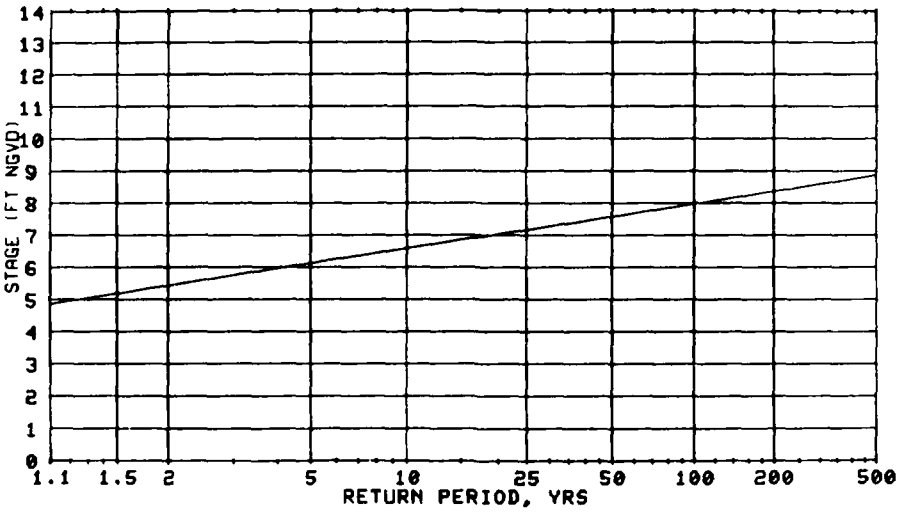
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 6(W END OF I-36 BRIDGE)



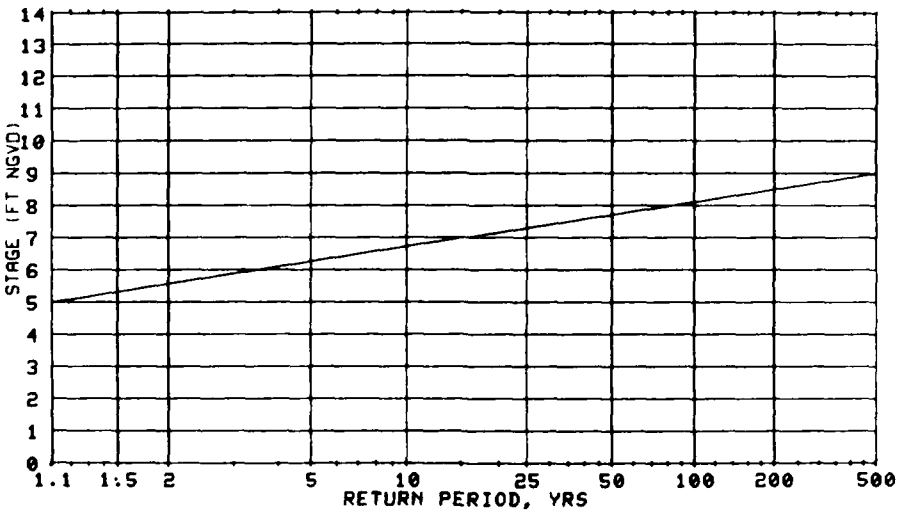
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 7(NAVESINK BEACH)



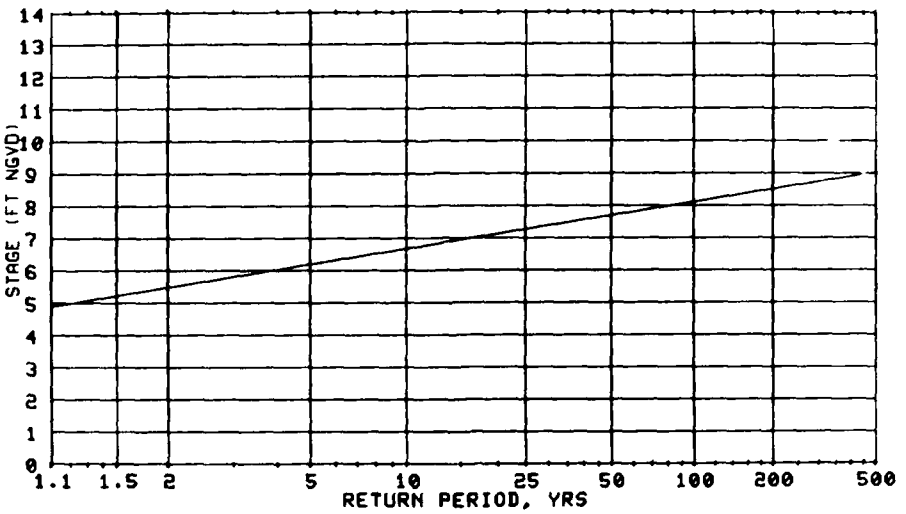
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 8(ENTRANCE OF NAVESINK R.)



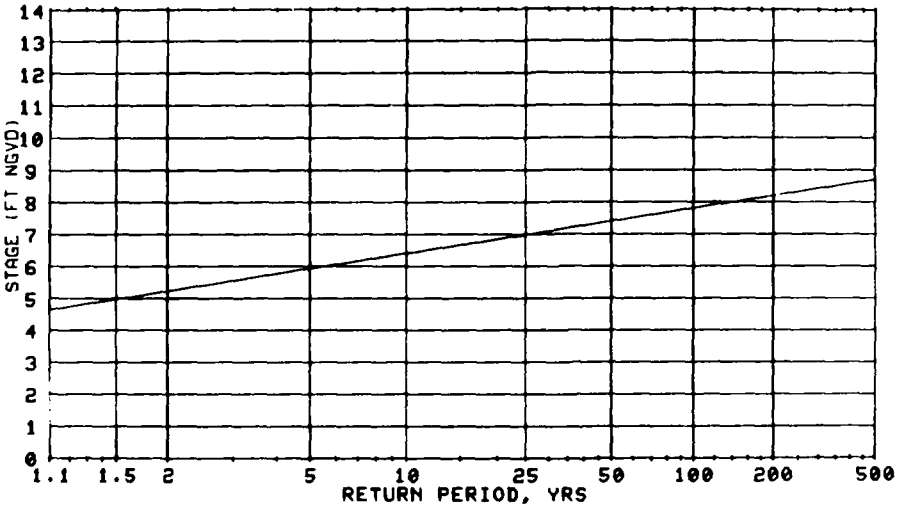
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 9(ENTRANCE OF CLAYPIT CREEK)



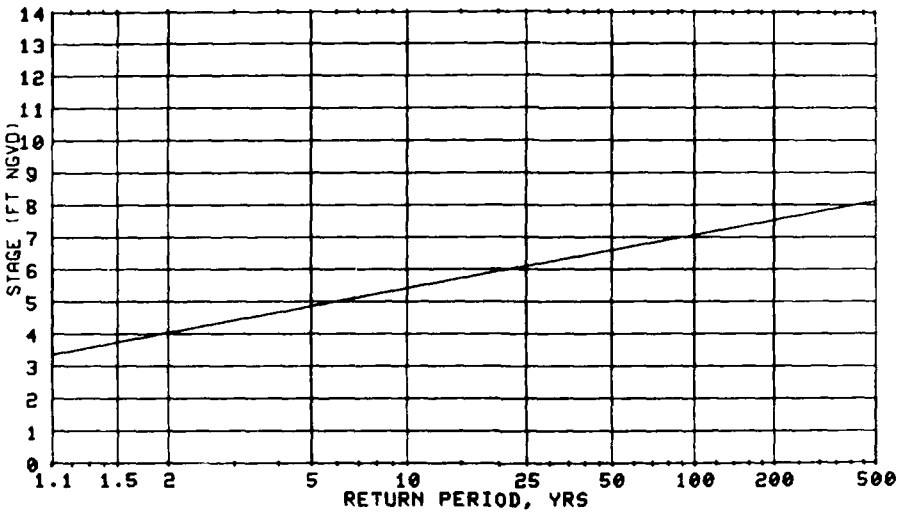
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 10(E OF NORMANDIE)



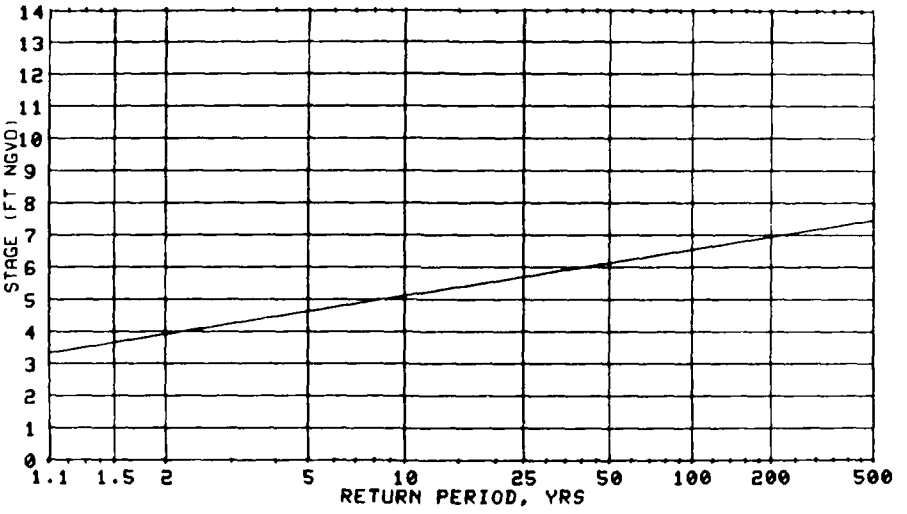
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 11(RUMRUNNER REST., SEA BRIGH



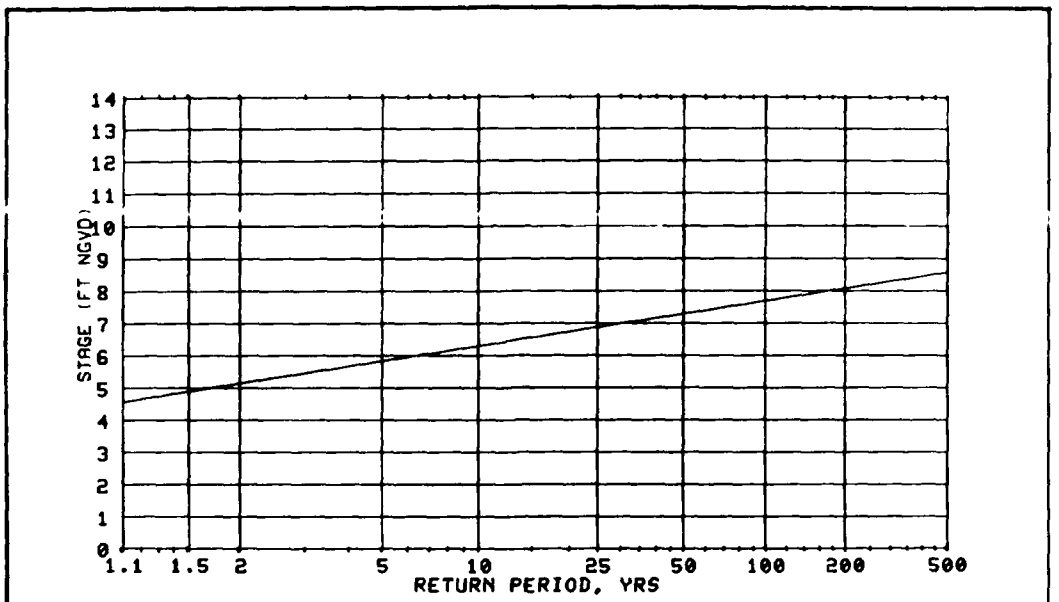
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 12(E FRONTAGE & EXT. OF HACEN



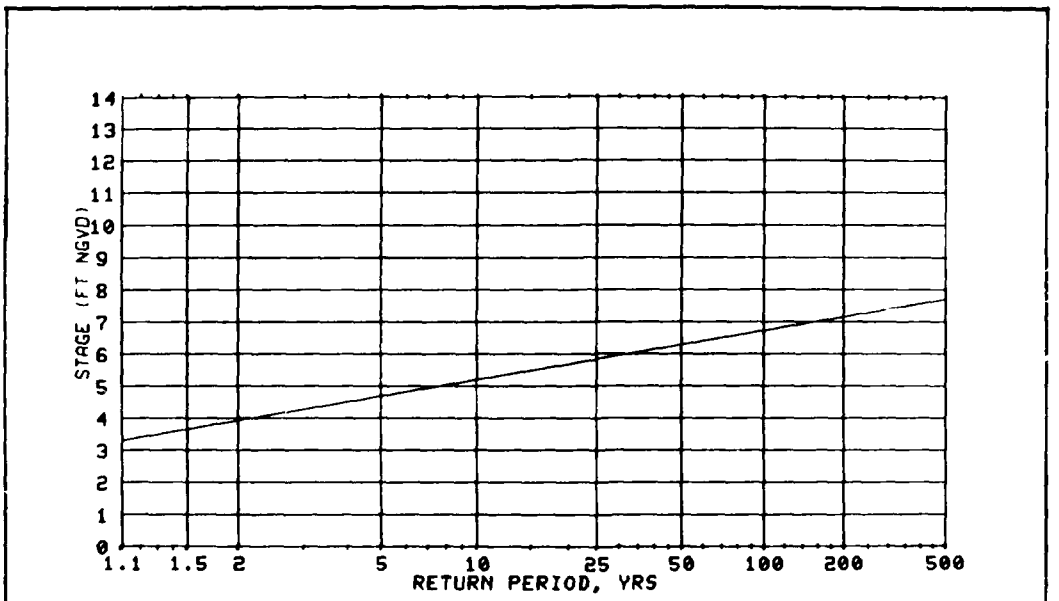
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 13(SEA BRIGHT)



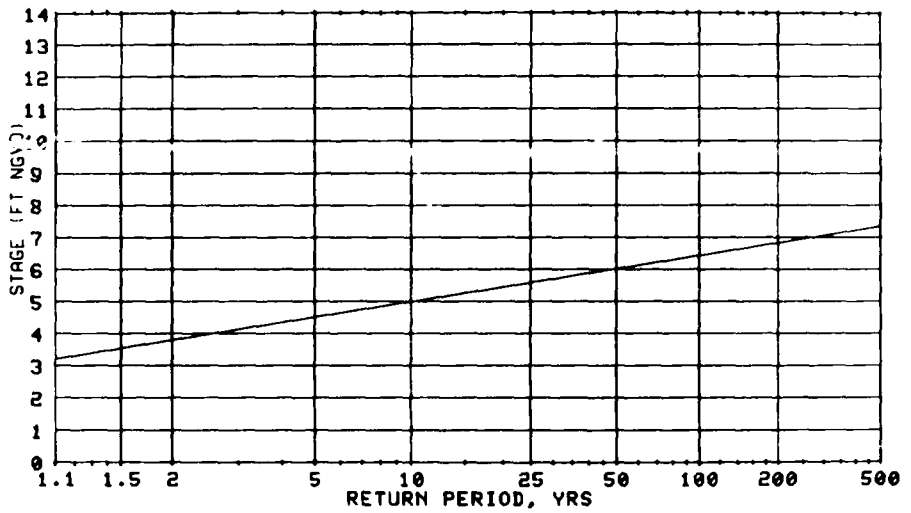
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 14(E OF THE ENTRANCE OF OYSTE



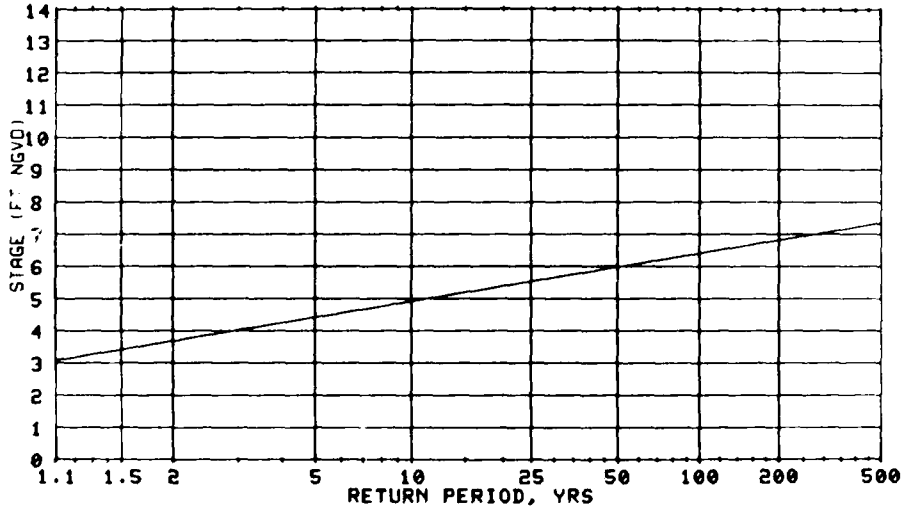
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 15(MAPLE AVE. & E. FRONTAGE)



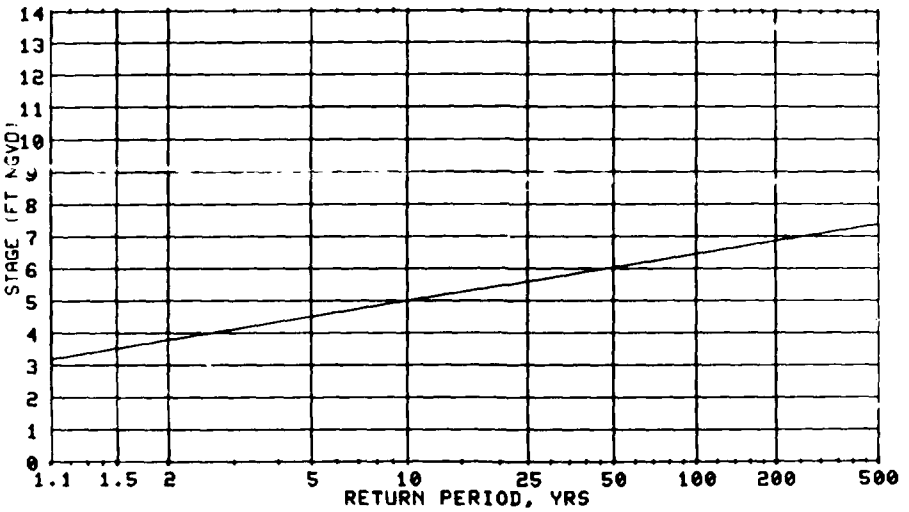
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 16(SHREWSBURY AT LOW MOOR)



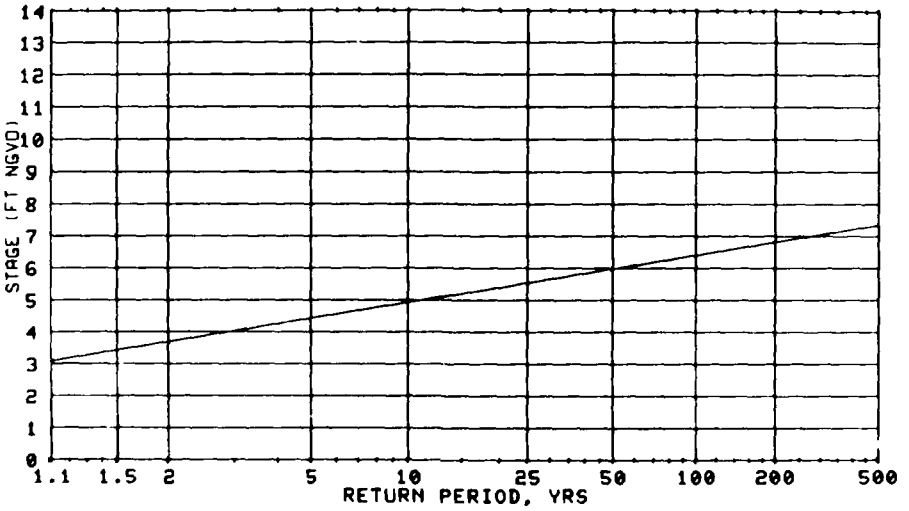
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 17(BTW. GALILEE & RACOON)



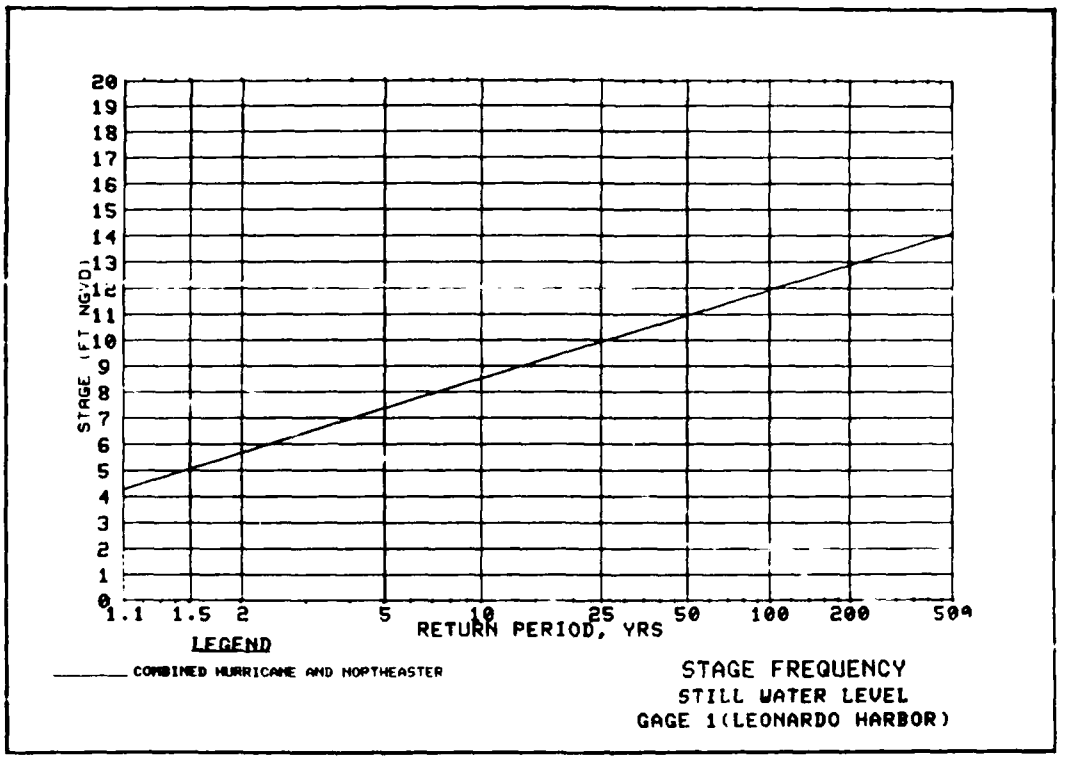
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 18(TIP OF SILVER PT. RD)



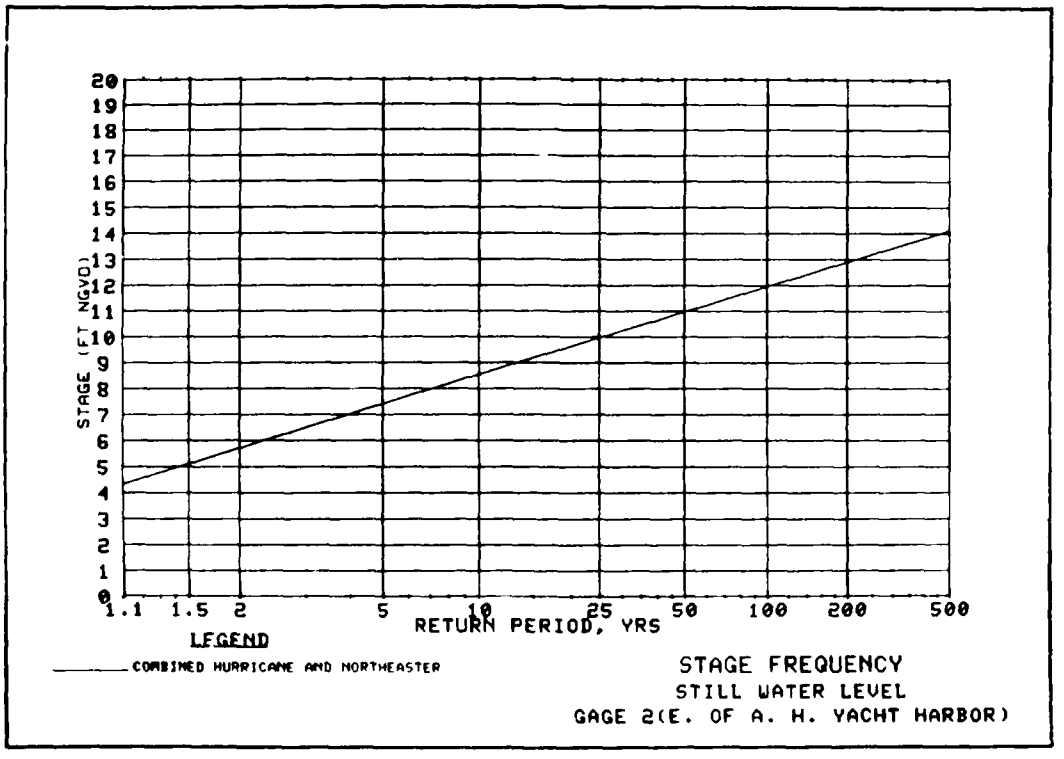
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 19(GALILEE)



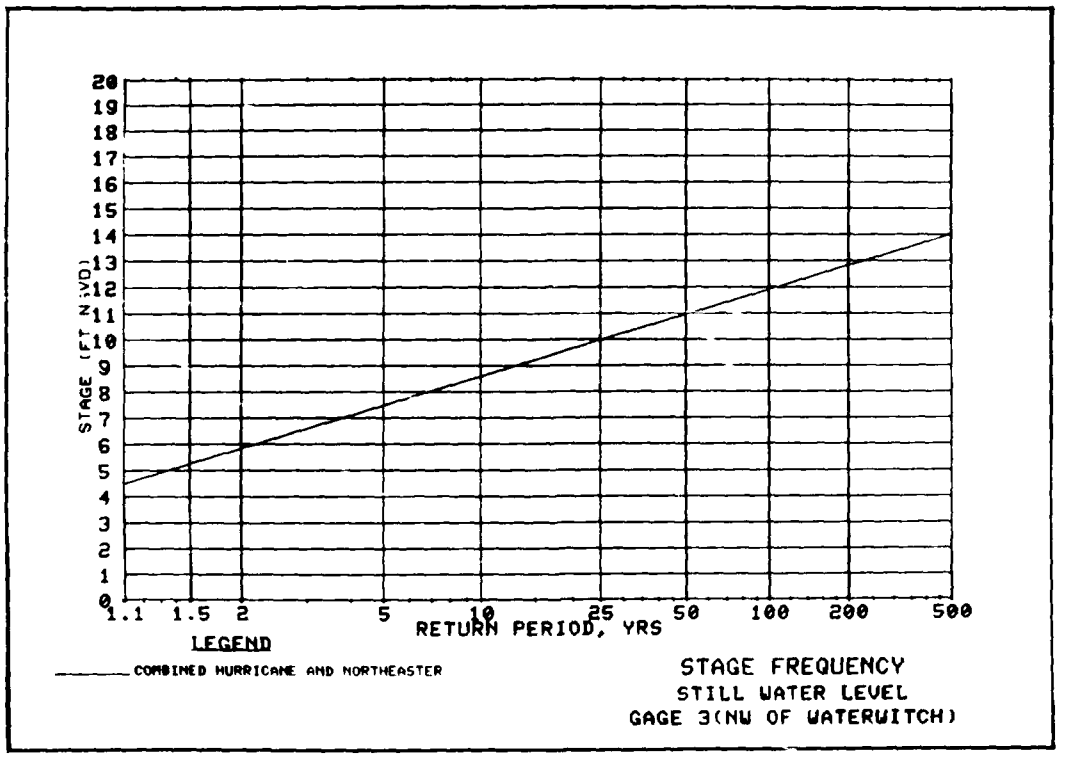
STAGE FREQUENCY
STILL WATER LEVEL
NORTHEASTER
GAGE 20(RACOON, PLEASURE BAY)



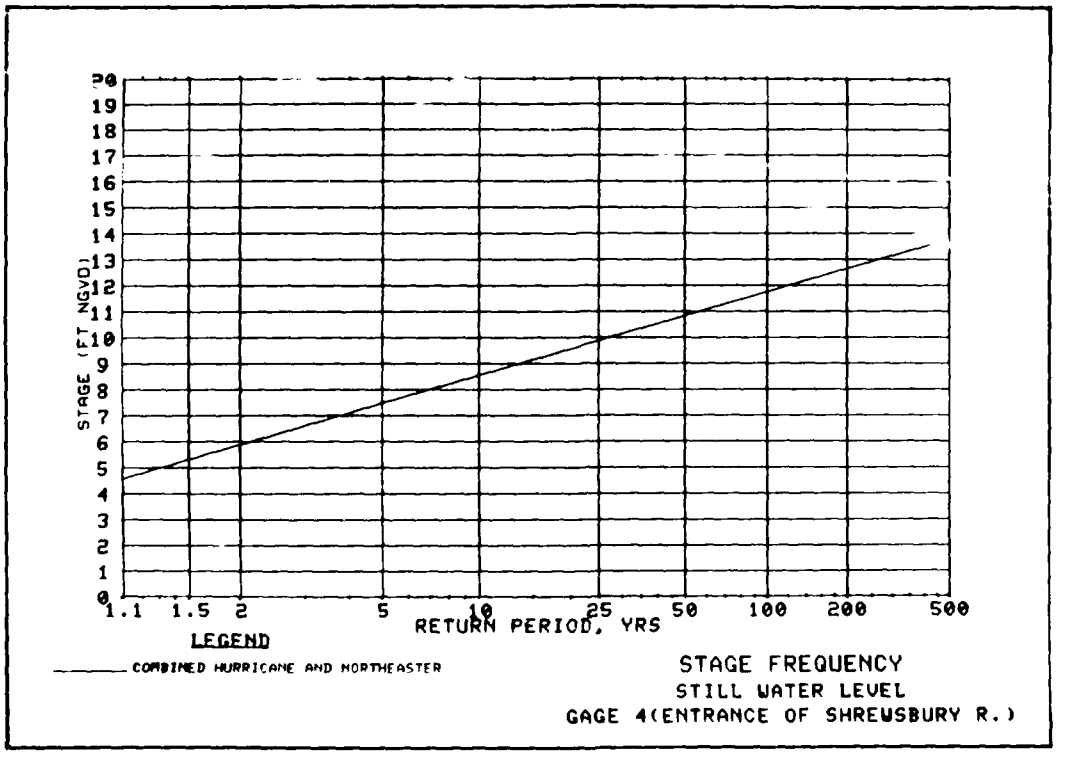
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 1(LEONARDO HARBOR)



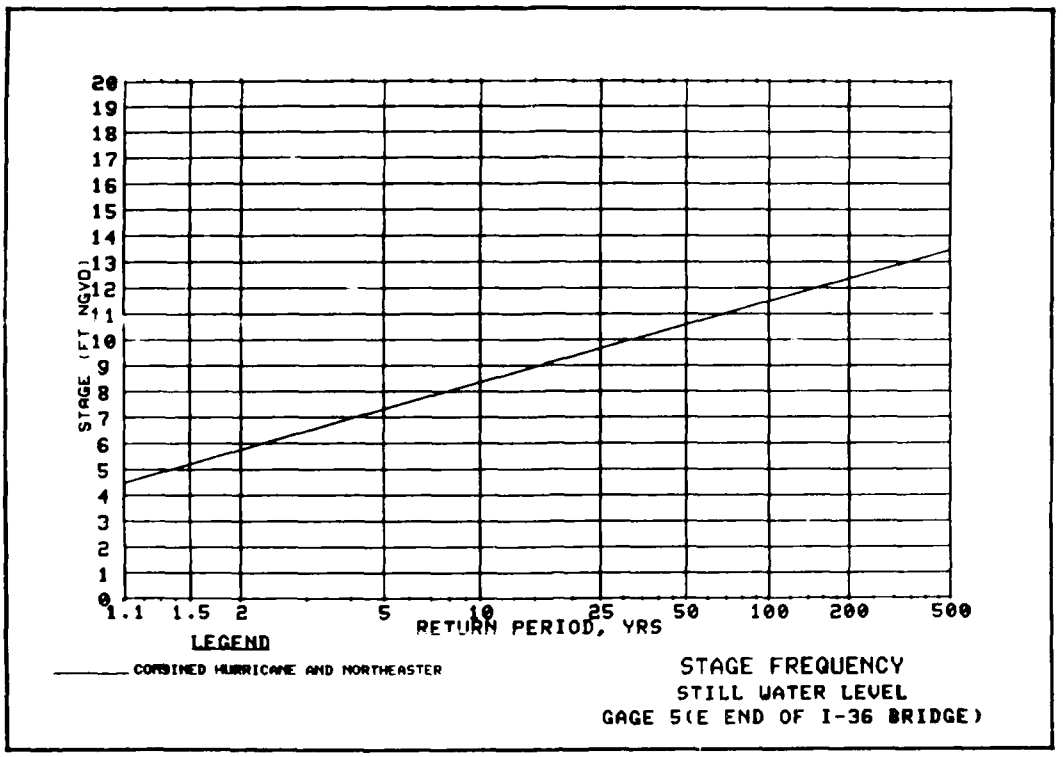
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 2(E. OF A. H. YACHT HARBOR)



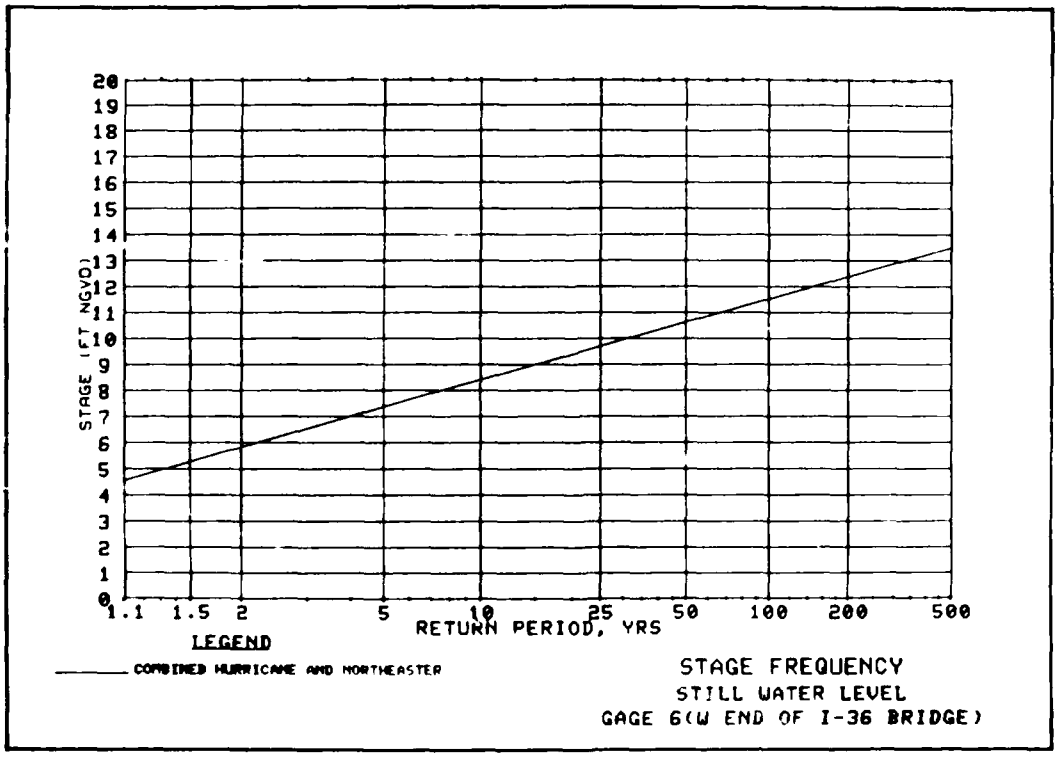
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 3(NW OF WATERWITCH)



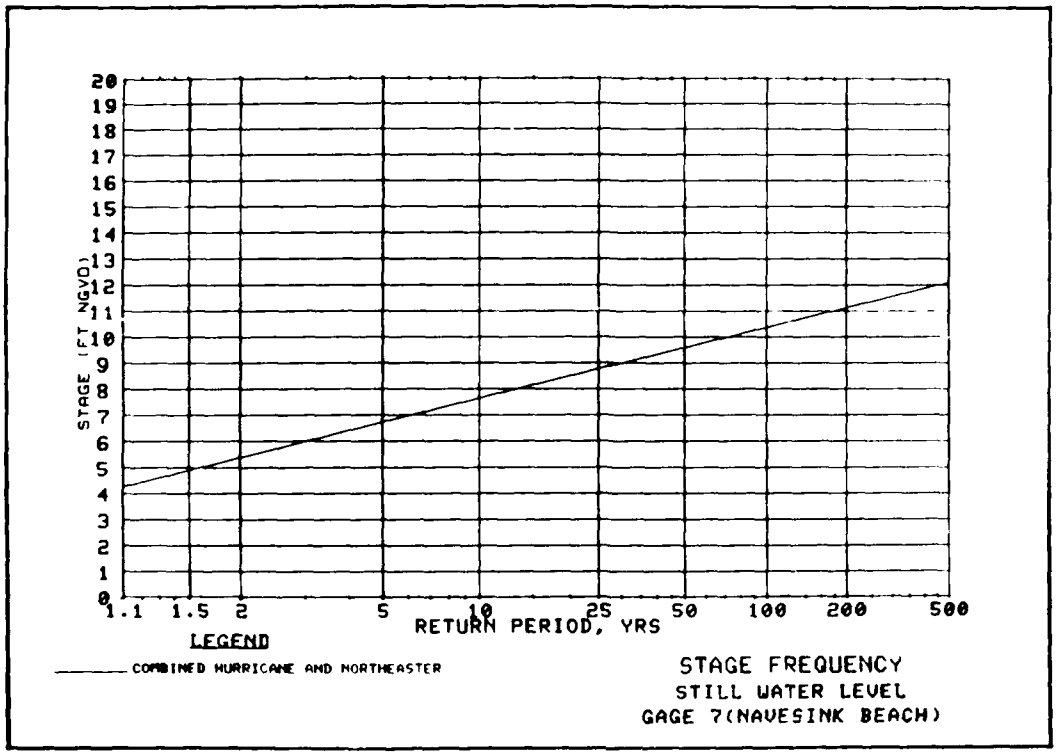
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 4(ENTRANCE OF SHREWSBURY R.)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 5(E END OF I-36 BRIDGE)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 6(W END OF I-36 BRIDGE)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STAGE (FT NGVD)
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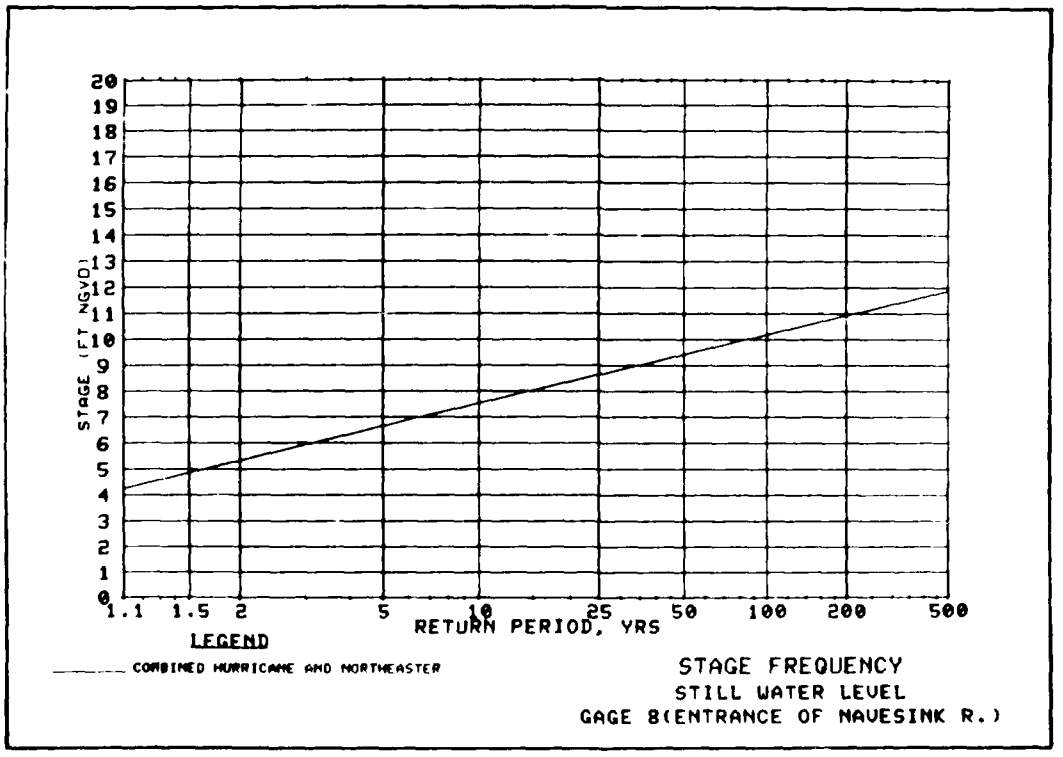
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 7(NAVESINK BEACH)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STAGE (FT NGVD)
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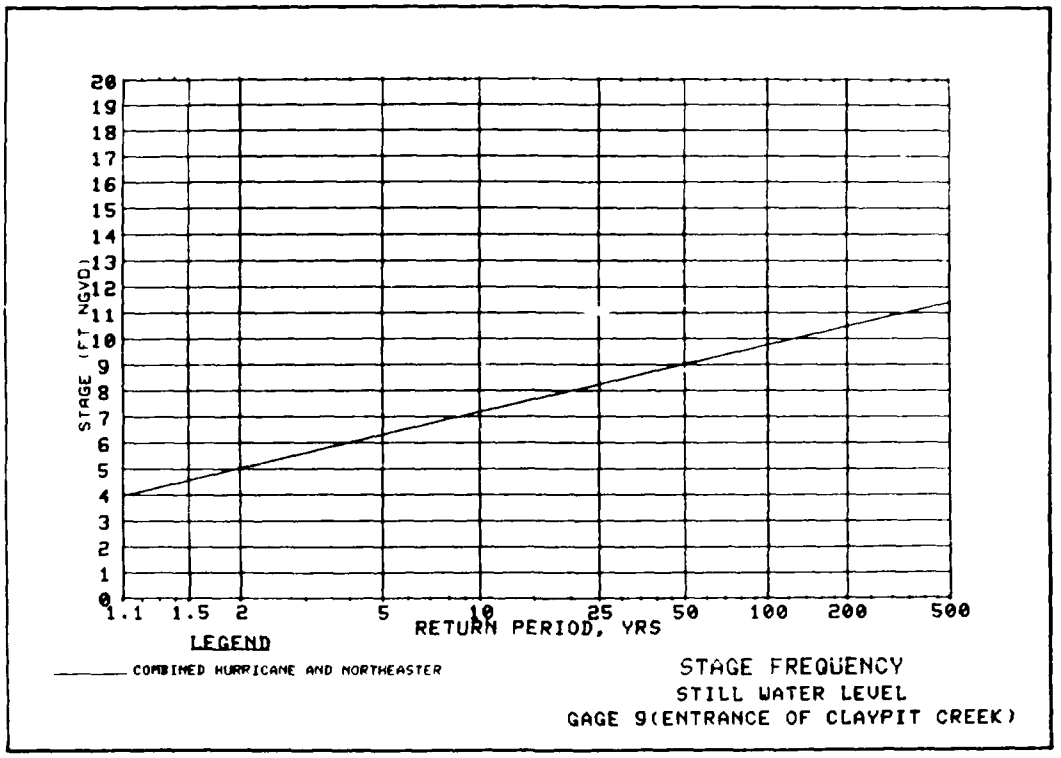
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 8(ENTRANCE OF NAVESINK R.)


STAGE (FT NGVD)
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100
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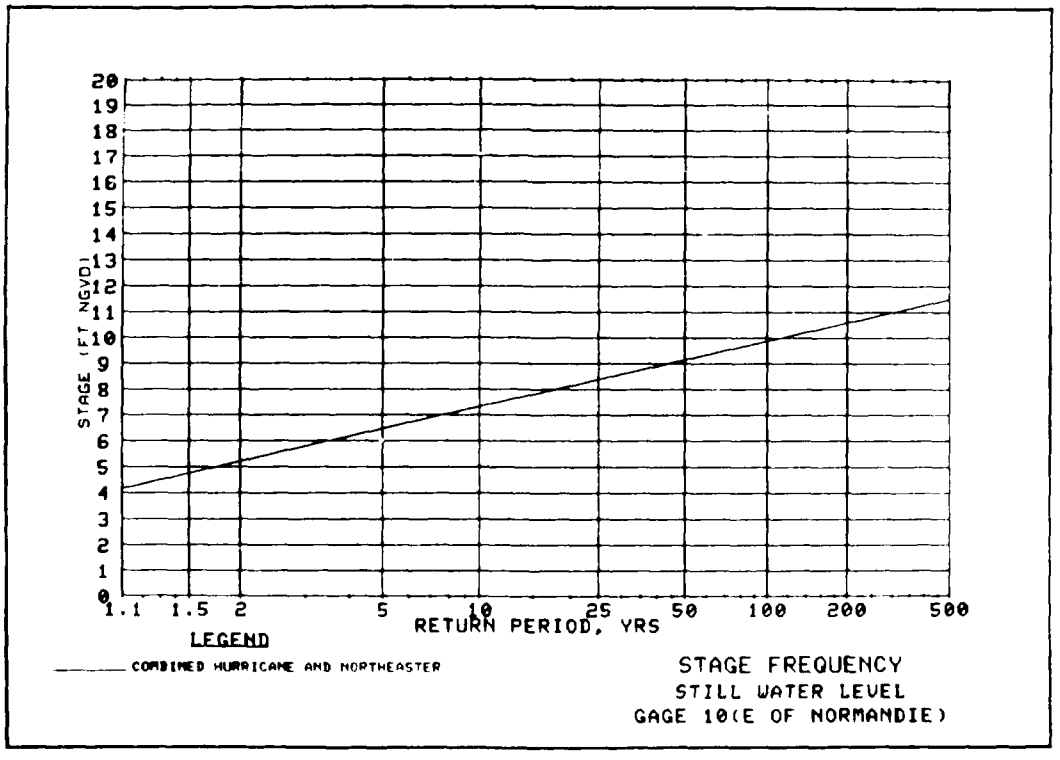
500
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 9(ENTRANCE OF CLAYPIT CREEK)


STAGE (FT NGVD)
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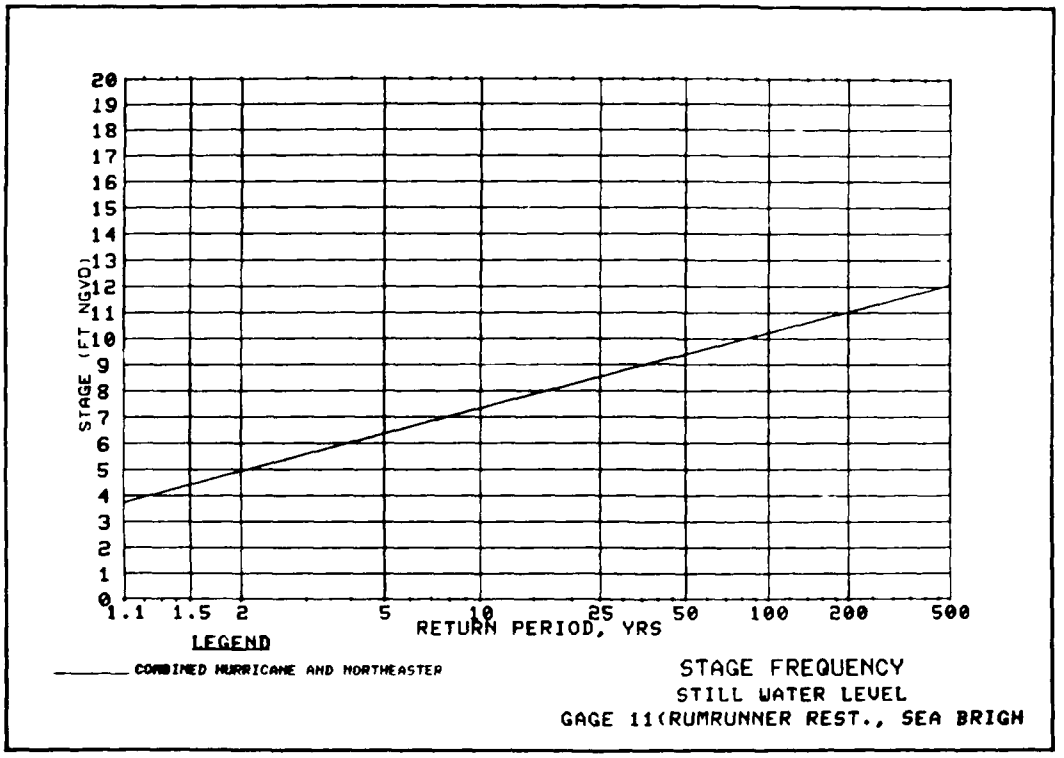
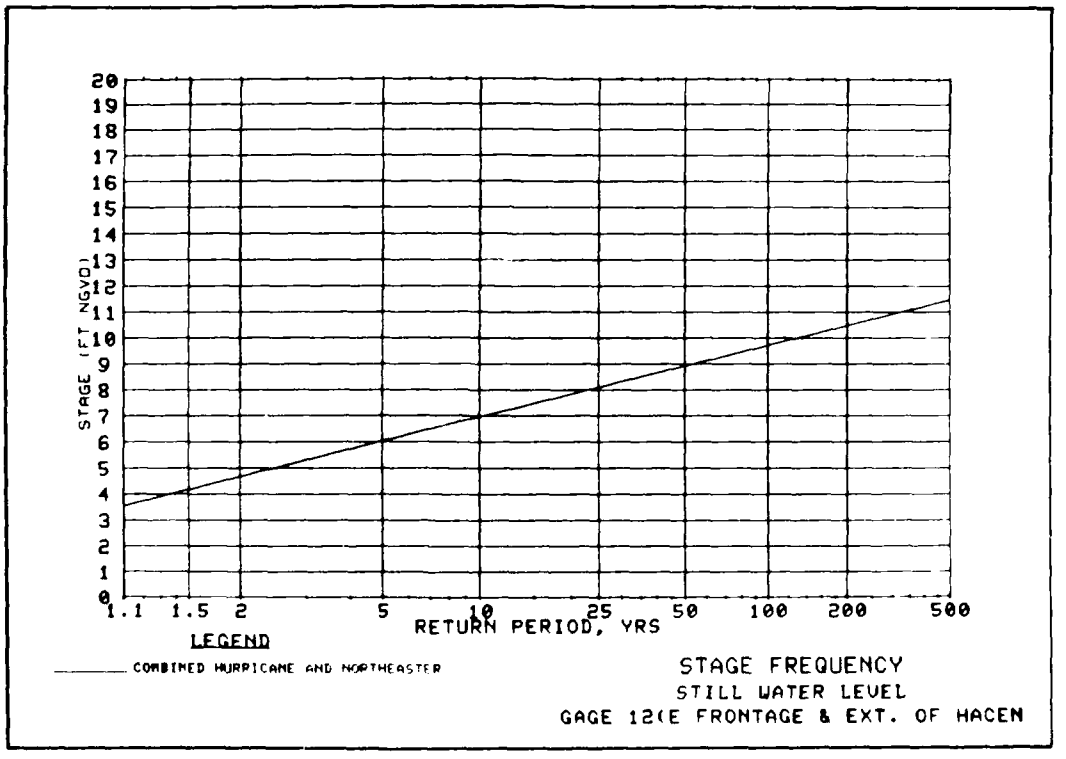
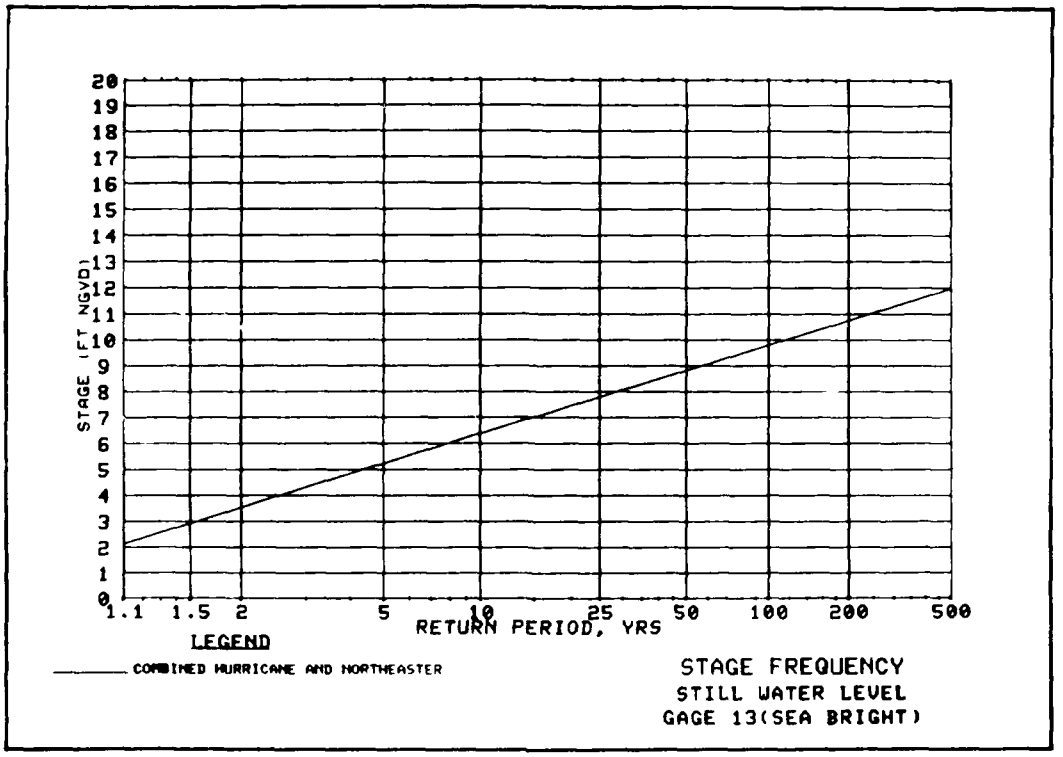
500
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 10(E OF NORMANDIE)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 11(RUMRUNNER REST., SEA BRIGH



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 12(E FRONTAGE & EXT. OF HACEN


STAGE (FT NGVD)
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200
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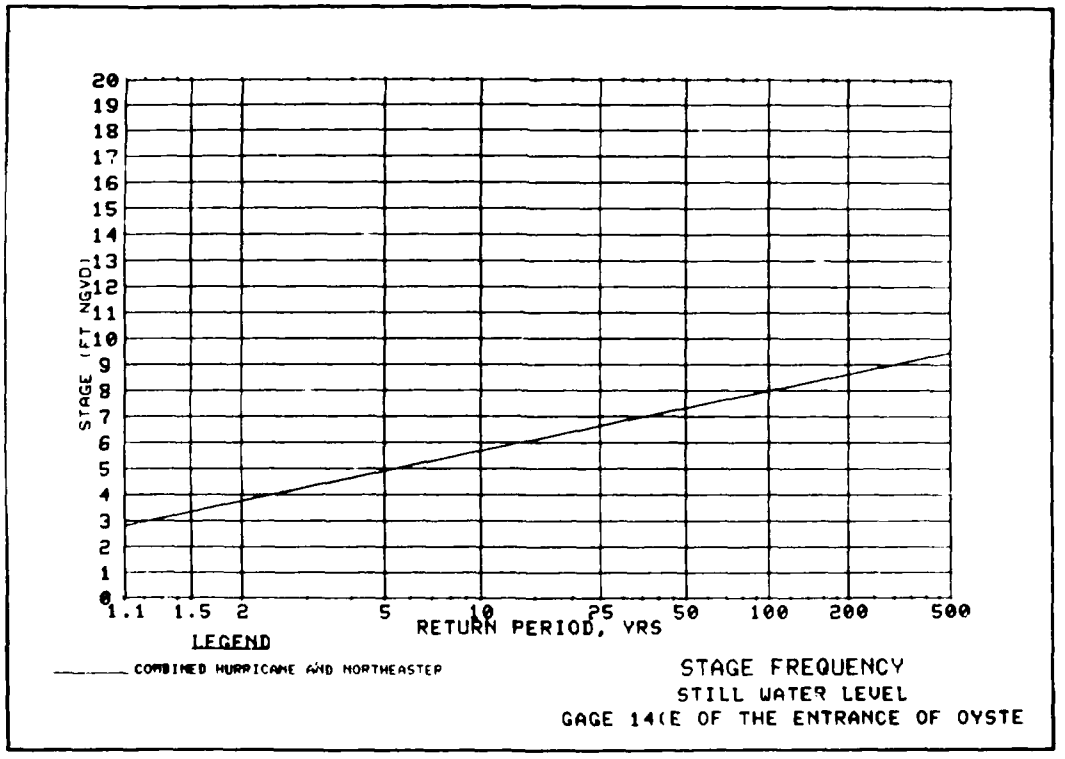
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 13(SEA BRIGHT)


STAGE (FT NGVD)
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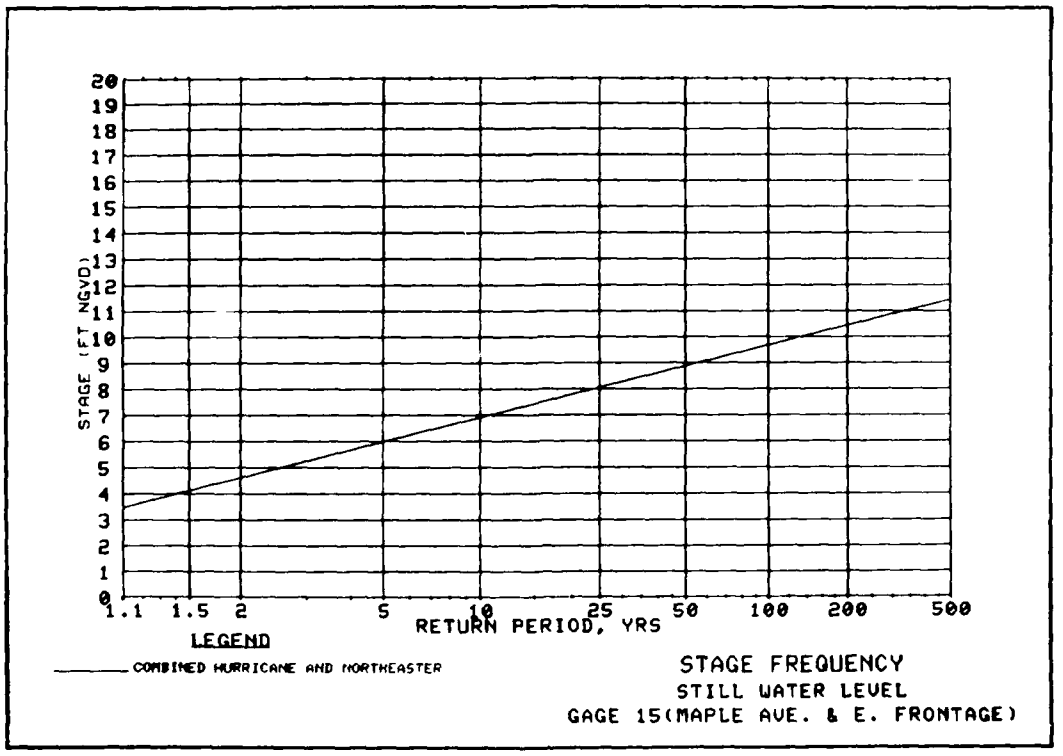
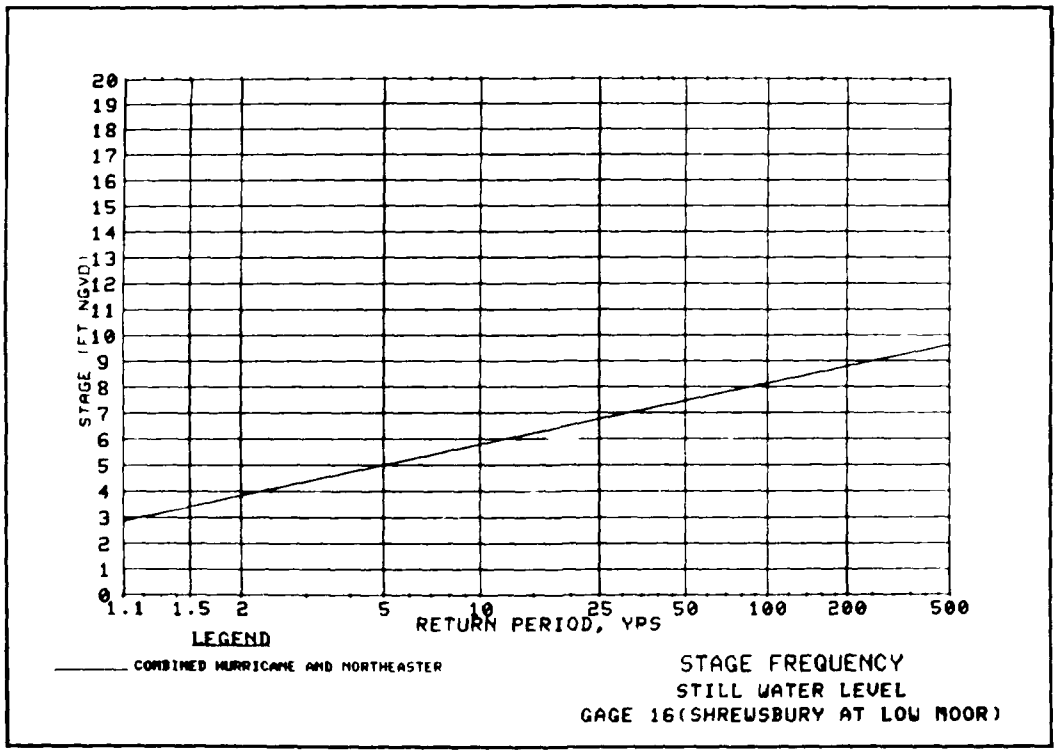
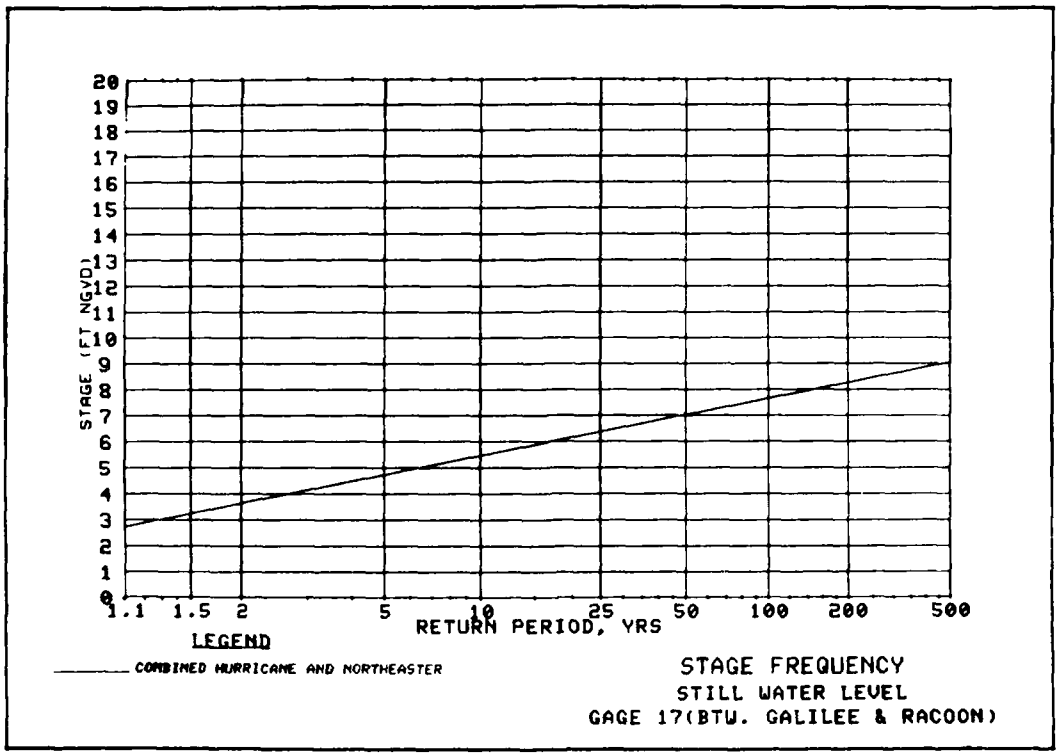
100
200
500
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 14(E OF THE ENTRANCE OF OYSTE



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 15(MAPLE AVE. & E. FRONTAGE)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 16(SHREWSBURY AT LOW MOOR)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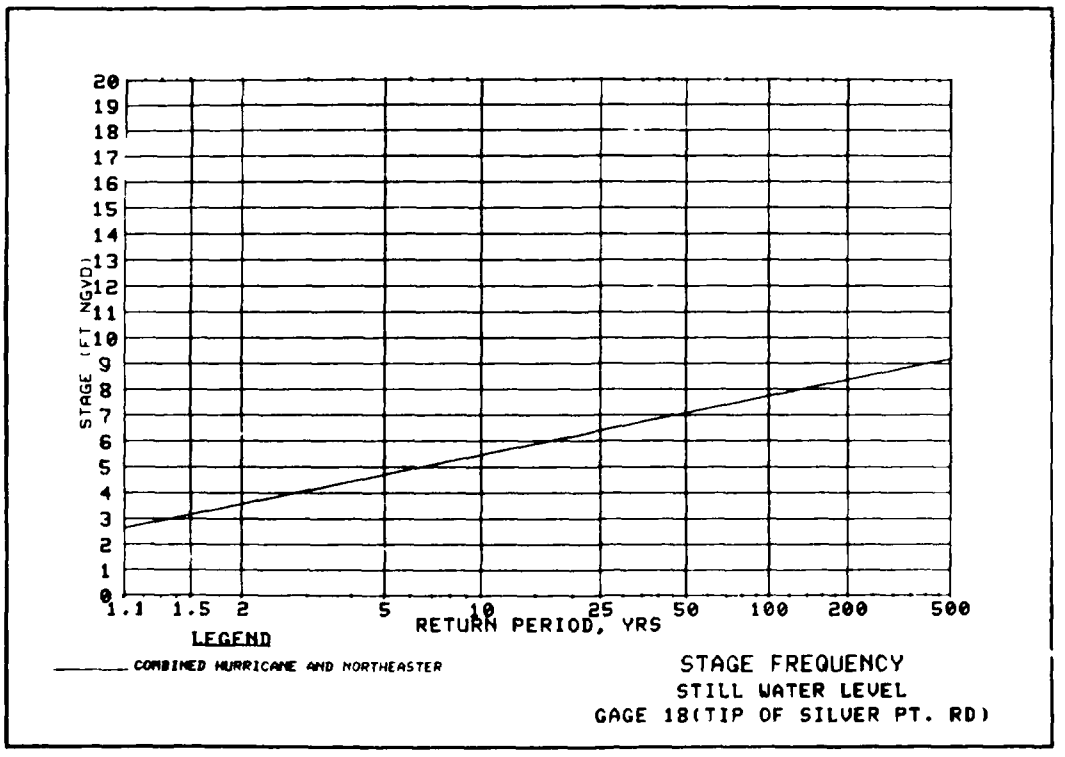
STAGE (FT NGVD)
1.1 1.5 2 5 10 25 50 100 200 500
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 17(BTW. GALILEE & RACOON)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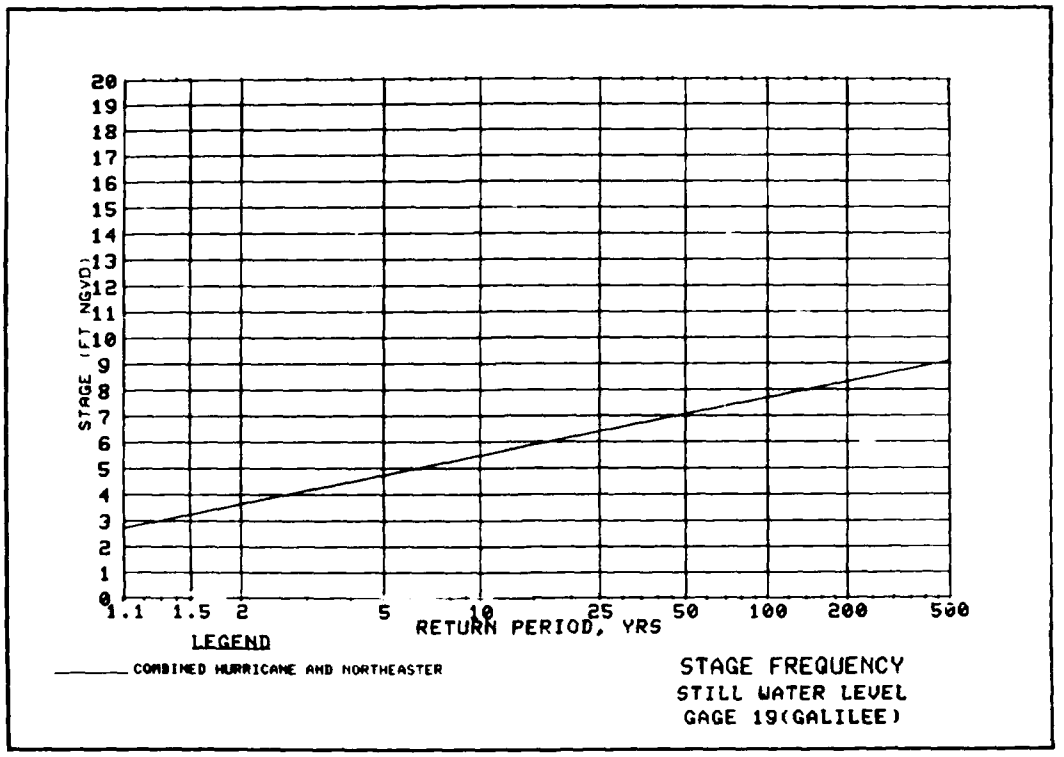
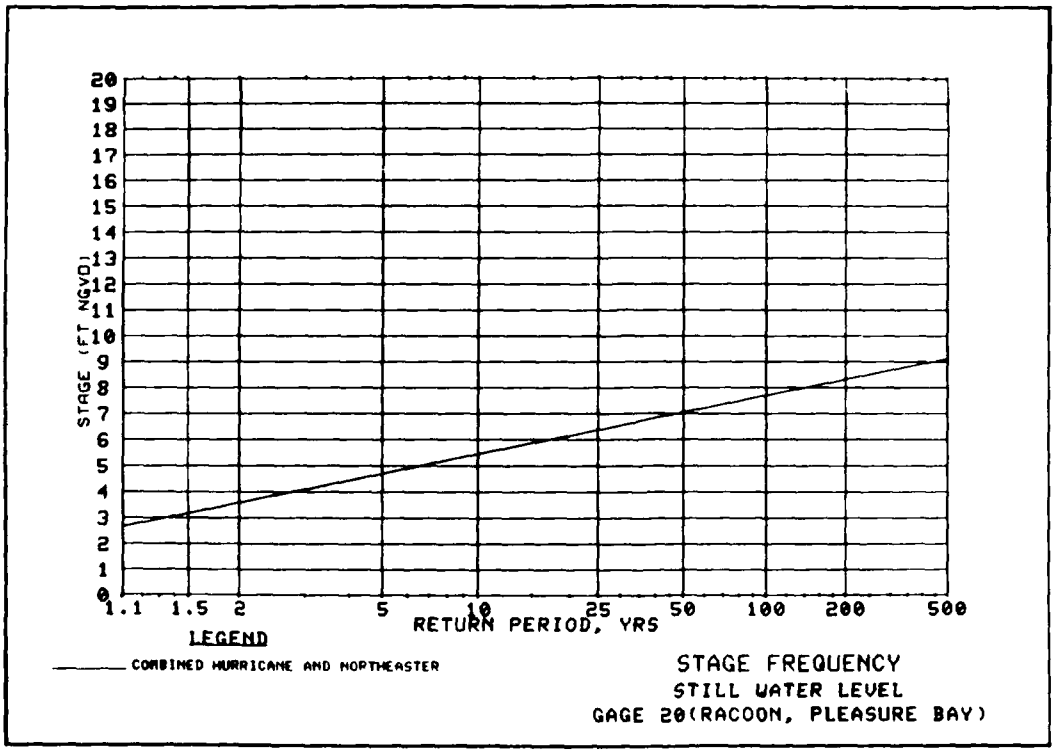
STAGE (FT NGVD)
1.1 1.5 2 5 10 25 50 100 200 500
RETURN PERIOD, YRS
LEGEND
COMBINED HURRICANE AND NORTHEASTER
STAGE FREQUENCY
STILL WATER LEVEL
GAGE 18(TIP OF SILVER PT. RD)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 19(GALILEE)



STAGE FREQUENCY
STILL WATER LEVEL
GAGE 20(RACOON, PLEASURE BAY)